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Concreting Track Laid With Continuous Rail.



"The Giant," the Electrically Driven Rail Crimping Machine Operated in Chicago Last November.

CONTINUOUS RAIL FOR CHICAGO STREET TRACTION.—[See page 197.]

The Upward Trend of Mortality in Middle Life and Old Age*

A Danger Signal and Its Meaning

By E. E. Rittenhouse

A RECENT newspaper article telegraphed from London states that Dr. Newsholme, Medical Officer of Health to the Local Government Board, created something akin to a scare with the statement in his annual report that the death rate among men above age 55 is increasing.

This increase must have been very slight, for the Registrar General's reports, 1880 to 1910, show that in England and Wales both the general death rate and the rate for males have decreased in all age groups up to age 65, although in the later ages the decreases have been small.

If a slight increase in the mortality in one age group is sufficient to excite such interest in Great Britain, what ought we to expect of the American people, among whom the mortality from diseases of middle life and old age has advanced in far greater ratio and at still younger ages?

It is quite generally believed by physicians and by those who have studied this angle of our mortality tendencies, that the important and hardest-worked organs of the body are wearing out and breaking down too soon, and that to the rising mortality rate from the chronic diseases of these organs is largely due the upward trend in the general death rate in the later age periods.

There are those, however, who assert, obviously without investigation or analysis of the public statistics bearing upon the subject, that neither of these increases has taken place.

And there are still others, some of them prominent in the health movement, who express the opinion, also apparently without reference to the records, that the increase is natural and to be expected. Their theory is that the increase, whatever it may be, is due to the saving of lives in the younger ages chiefly from communicable disease; that these lives passing into the older periods, many of them with weakened power of resistance, have given us more old people to die than we formerly had.

At first glance this is perhaps a natural conclusion, but the records show that there has been little or no increase in the number surviving to the later years of life. Even if there were such an increase, it would merely lead to a correspondingly increased number of deaths at the later ages, and not to an increase in the death rate at these ages, which is the ratio between the number dying and the number living.

The saving of infant and early adult lives which have been attacked by the communicable diseases has been so recent that but a small proportion of them have passed into the older age periods. And it must also be remembered that they were not all left impaired; that the same influences that have reduced the death rate in the younger ages have saved a large number of people from attack by the same diseases, and also strengthened the vitality of many people, both fit and unfit, thus permitting an increase of healthful, unimpaired lives also to pass over into the older age periods. If any net gain in the general death rate has occurred from these causes, it appears to have been overcome by the heavy increase in the loss from degenerative maladies.

The distribution of deaths and of population by age periods is not available for the entire country, owing to the well-known incompleteness of our vital statistics. But taking what seems to be the most dependable and complete data we have on this subject, we find the following in Massachusetts and New Jersey: In 1880 there were in each 1,000 of the general population 264.2 people age 40 and over, and in 1900 265.8 people in the same group, an increase of six tenths of one per cent.

In the same group there were in 1880 25.1 deaths for each 1,000 population, and in 1900 30.1 deaths, an increase of 20 per cent.

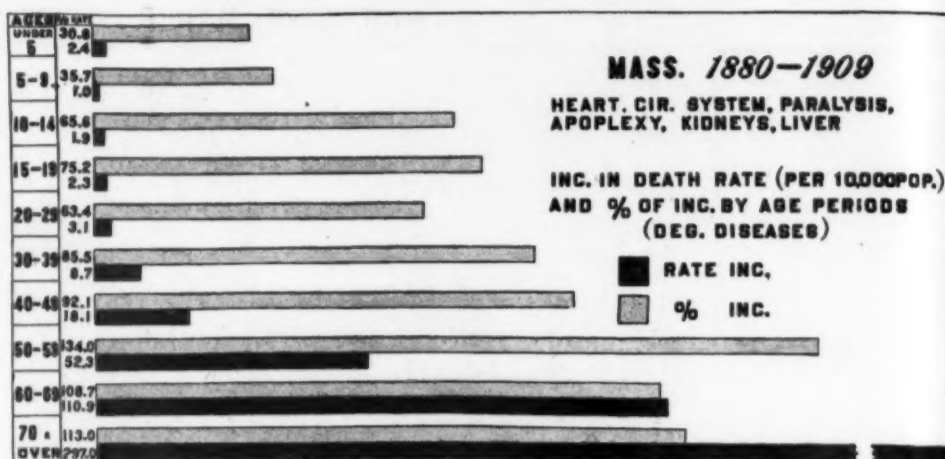
LIFE INSURANCE AND HEALTH CONSERVATION.

Every postponable death among policyholders increases the cost of life insurance.

The mortality gains, which are the annual sums by which the expected death claims exceed the actual claims, go into the surplus from which dividends are paid to policyholders. Therefore, it is obvious that if the present mortality rate among policyholders could be maintained at a lower level, the cost of insurance to them would be reduced.

* Address given before Section I of the American Association for the Advancement of Science, Cleveland, Ohio, January 3rd, 1913.

1910 census age distribution of population had not been issued when this paper was written.



Increase in Death Rates from Degenerative Diseases in Massachusetts During the Period from 1880 to 1900.

This briefly explains one of the reasons why a life assurance society should assist in the campaign to promote longevity.

There are in this country about 240 life insurance companies, the most of them very small, having about 25,000,000 policyholders. While some life insurance companies and organizations are showing evidences of interest in the health conservation movement, and extending "moral" support when opportunity offers, but three or four are helping by organized effort and the actual expenditure of money in the conservation campaign among policyholders and the public.

In infancy, childhood and early adult life, where the smaller portion of policyholders are found, the death rate has been decreasing for years. In middle life and beyond, where the larger group of policyholders is found, the mortality trend, especially in our cities, appears to have been steadily upward. Only two companies are giving especial attention in their conservation work to the excessive life waste in these older groups.

It must not be understood from this that the mortality experts of the great life companies have overlooked the advancing ratios in the older age periods from degenerative causes. This has been evidenced by increasing severity in medical examinations at these ages, and in some instances by an advance in premiums.

DEGENERATIVE DISEASES.

That the ratio of deaths from the chronic affections of the vital organs has increased sharply in recent years, is so generally known that it is needless to present in this brief paper the indicated advance in the rate for each disease separately. They are, therefore, grouped (in Table I) by age divisions. By this method the disturbing effect on the rates of any changes in classification or improvement in diagnosis is largely overcome. The most reliable records available for this purpose, giving age divisions in 1880, are those of Massachusetts. While the death rates in childhood and early adult life are relatively small, they show a significant increase, especially at ages 10 to 20.

Included in this group are apoplexy, paralysis and diseases of the heart, circulatory system, kidneys and liver.

The estimated deaths in 1910 from these diseases in the United States (based upon the Reg. area) were 367,700.

TABLE I. DEGENERATIVE DISEASES

MASSACHUSETTS 1880-1900 (b).—INCREASE IN THE DEATH RATE PER 10,000 BY AGE PERIODS.

Ages.	1880.	1900.	Increase.	Per Cent of Same.
All	23.21	43.26	20.05	86.38
Under 5	7.92	10.36	2.44	30.8
5-9	2.91	3.95	1.04	35.7
10-14	2.85	4.72	1.87	65.6
15-19	3.10	5.43	2.33	75.2
20-24	4.95	8.09	3.14	63.4
25-29	10.13	18.79	8.66	85.5
30-34	19.70	37.84	18.14	92.1
35-39	39.01	91.30	52.29	134.
40-44	102.05	212.93	110.88	108.7
45-49	261.1	558.2	297.	113.

Since 1880 the mortality rate from this group of diseases in England and Wales has been virtually stationary, (c) although it has increased in some of them.

The most important of the other diseases of middle

b. Mass. State Registration Reports.

c. Annual Reports of the Registrar General (London).

life and old age that have increased is cancer. Comparing 1910 with 1880, the cancer death rate has increased in Massachusetts 66 per cent; since 1900 it has increased 31 per cent. External cancer alone has increased in the entire registration area 55 per cent since 1900 (d).

Table II brings the comparisons in a smaller group (organic heart, apoplexy, kidneys) up to 1910 by certain States and cities.

TABLE II. ORGANIC HEART, APOPLEXY, KIDNEYS

	Rate increased from 1880 to 1900	Rate increased from 1900 to 1910	Per Cent increase
Sixteen cities (f) 1880-1910—30 yrs.	17.95	34.78	94
New Jersey 1880-1910—30 yrs.	16.52	34.30	108
Ten Regist'n States (g) 1900-1910—10 yrs.	30.67	36.46	19

It will be noted that the increase continues from 1900 to 1910 in the ten States, which include a larger proportion of rural population than Massachusetts and New Jersey. The curves vary in different States and cities, but the same general trend is observed wherever statistics relating to these causes of death are available.

MORTALITY STATISTICS.

Much progress has been made in recent years in popularizing our vital statistics, but still much valuable information which should be placed before the public in concise and popular form, lies buried in our official records and in the files of our statisticians and scientists who have analyzed them for their own or scientific use.

We may regret that the registration area for vital statistics did not long ago embrace all of our population, and that it still does not do so; (a) we may deplore the fact that those we have are not as accurate or complete as they should be, but at the same time, we must recognize their very great value in showing the trend of mortality by diseases, ages, localities, etc., within the area where the international classification and the registration laws are in operation.

The need for caution in making allowances for inequalities, inaccuracies and varying conditions in comparing present day mortality data with those of former years is obvious, yet if the people are to know and act upon the message of our vital statistics, such lessons must not only be extracted, they must be placed before them, and in simple form or their significance will not be understood.

The statistics used in arriving at the comparisons given below were sufficiently complete to render unnecessary the interpolation of estimates to fill gaps or omissions with one unimportant exception (i). The rates deduced are the direct product of existing official reports, which are accessible to anyone desiring to look them up.

It should be remembered that the purpose of submit-

d. U. S. Mortality Statistics, 1900, Census Bulletin, 100, 1910.

f. 16 Cities: New York, Chicago, Philadelphia, Brooklyn, St. Louis, Baltimore, San Francisco, Cincinnati, Cleveland, New Orleans, Pittsburgh, Washington, Milwaukee, Louisville, Providence, Indianapolis.

g. Registration States in 1900 were: Massachusetts, New Jersey, Connecticut, Maine, Michigan, New York, New Hampshire, Rhode Island, Vermont, District of Columbia and Indiana. Indiana is omitted in comparisons owing to lack of uniformity in age distribution.

h. The Registration Area 1910 covered 58.3 per cent of the population of Continental U. S.

i. In the absence of the official figures of the age divisions of the population for 1910, the ratios of distribution of 1900 were used. Inasmuch as the change in the percentage of living at the different age periods is very slight in one decade, the actual ratios for 1910 will make no appreciable change in the mortality rates here given.

ting these ratios is not primarily to fix the rate, but to indicate the trend of mortality in middle life and old age in the area named. Those interested in the subject will judge the measure of the actual increase by the value they may place upon the original data from which these rates are extracted.

GENERAL DEATH RATE—INCREASE IN OLDER AGES.

In his report upon national vitality in 1907 Prof. Irving Fisher of Yale presented a table showing the increases and decreases in the death rate by age periods in Massachusetts in 1865-1900, upon which he comments as follows:

"Here, while the death rate for all age periods under 40 has materially decreased, the later periods of life have suffered progressive increase in mortality rate."

His belief is that:

"The mortality after middle age is growing worse and the vitality of the people is, in all probability, deteriorating."

The mortality rates deduced from the registration area reports, and presented herein, tend to confirm Prof. Fisher's conclusions, and the belief of many others, that the increasing loss of life from these chronic diseases is reflected in the general death rate at the ages at which these afflictions are most common.

In 1880 the comparisons are confined to Massachusetts and New Jersey, and to 16 registration cities, because in these areas we have the most reliable statistics (j) of that time, from which these comparisons can be carried through to 1910. They virtually constitute the first registration area data.

A comparison of the average rate for each five years preceding 1880 and 1910 would require the interpolation of certain estimates. This has not been done for the reason that both 1880 and 1910 were normal (k) mortality years, and their rates are believed to represent a fair average. No epidemic or other unusual causes of death occurred among adults, and the death rate for 1880 seems to be less than the preceding and succeeding census years.

TABLE III. SIXTEEN (j) REGISTRATION CITIES
1880-1910

DECREASE AND INCREASE IN GENERAL DEATH
RATE BY AGE PERIODS. (m)

Ages.	D. R. 1880.	D. R. 1910.	Dec. and Inc. in Rate.	Per Cent of Same.
All	22.09	16.36	-5.73	-26.
Under 35	21.4	11.36	-10.04	-47.
35-44	13.6	12.29	-1.31	-9.6
45-54	18.3	22.07	+3.77	+20.6
55-64	29.3	37.54	+8.24	+28.1
**65 & over & ages un- known	80.3	89.30	+9.0	+11.2
Above 45	32.	40.10	+8.10	+25.31
Above 55	48.44	58.82	+10.38	+21.43

j. "The State and municipal registration records were copied and are used in the tabulations instead of the enumerators' schedules. These State and municipal registration records are based on a system of burial permits, and are therefore probably very nearly accurate. This fact should be borne in mind in comparing the reported mortality of these with that of other localities."—U. S. Census Report 1880.

k. "The census year 1879-1880 was probably a fair average year as regards mortality. No great epidemic occurred during this period, unless we may consider a marked prevalence of diphtheria as such."—U. S. Census Report 1880.

l. In 1890 the mortality rates were abnormally high at virtually all ages, which minimizes their value in making comparisons to show the trend; notwithstanding this, a comparison of 1890-1910 (not shown here) indicates an advance in the rates at the older ages.

See foot-note j, page 194.

m. U. S. Mortality Statistics. See foot-note i, page 194.

** Accuracy of this is impaired by including deaths at unknown ages.

TABLE IV. MASSACHUSETTS AND NEW JERSEY
1880-1910

DECREASE AND INCREASE IN GENERAL DEATH
RATE BY AGE PERIODS. (m)

Ages.	D. R. 1880.	D. R. 1910.	Dec. and Inc. in Rate.	Per Cent of Same.
All	17.63	15.80	-1.83	-10.38
Under 30	16.3	11.3	-5.0	-30.6
30-34	9.12	6.99	-2.13	-23.3
35-39	10.1	8.90	-1.20	-11.8
40-44	10.20	10.95	+.75	+7.35
45-49	12.20	13.79	+1.59	+13.0
50-54	13.70	18.35	+4.65	+33.9
55-59	20.49	24.28	+3.79	+18.5
60-64	25.69	34.85	+9.16	+35.6
65-69	40.5	53.16	+12.66	+31.2
70-74	55.4	75.96	+20.56	+37.1
75 & over	123.68	143.66	+19.98	+16.1
All ages.				
Above 40	25.10	30.42	+5.32	+21.20
Above 50	35.24	44.07	+8.83	+25.06
Above 60	53.81	67.73	+13.92	+25.87

TABLE V. TEN (n) REGISTRATION STATES 1900-1910

DECREASE AND INCREASE IN GENERAL DEATH
RATE BY AGE PERIODS. (m)

Ages.	D. R. 1900.	D. R. 1910.	Dec. and Inc. in Rate.	Per Cent of Same.
All	17.29	15.88	-1.41	-8.15
Under 30	13.44	10.98	-2.46	-18.3
30-34	8.81	7.19	-1.62	-18.4
35-39	10.04	9.07	-.97	-9.7
40-44	11.03	10.98	-.05	-.45
45-49	13.58	14.19	+.61	+4.5
50-54	17.26	18.42	+1.16	+6.7
55-59	24.17	24.04	-.13	-.5
60-64	32.26	33.74	+1.48	+4.6
65-69	47.86	51.09	+3.23	+6.75
70-74	69.99	73.44	+3.45	+4.9
75 & over	141.65	142.47	+.82	+.6
All ages.				
Above 40	29.85	30.74	+.89	+3.0
Above 50	42.64	44.02	+1.38	+3.23
Above 60	64.69	66.87	+2.18	+3.37

m. U. S. Mortality Statistics. See foot-note i, page 194.

n. U. S. Mortality Statistics. See foot-note g, page 194.

To summarize, the public records under consideration indicate that—

1. The mortality rate from apoplexy, paralysis, diseases of the heart, circulatory system, kidneys and liver has heavily increased in the younger as well as in the older groups. The total deaths were 367,700 in 1910.
2. In Massachusetts the death rate from these causes has increased 86.4% in 30 years.
3. In 16 important cities the death rate from organic diseases of the heart, and from apoplexy, Bright's and nephritis has alone increased 94% in 30 years.
4. In 10 registration states the death rate from these causes has increased 19% in ten years.
5. In Massachusetts the death rate from cancer has increased 66% in 30 years, and 31% during the past 10 years.
6. In the entire registration area the death rate from external cancer alone has increased 55% in 10 years,—from 1900 to 1910.
7. The increase in mortality from diseases of middle life and old age is reflected in the general death rate by an increase commencing in Massachusetts and New Jersey in age group 40-44; in 16 cities group 45-54; in 10 states group 45-49.
8. The death rate of the total population age 40 and over has increased, 1910 over 1880:

In Mass. & N. J. 30 years - - - - 21.2%
In 16 Cities, 30 years - - - - 25.3%
In 10 States, 10 years (1900-1910) - 3.0%

The increase in the proportion of older lives in our population has been very slight and does not account for the increase in the death rate.

To what extent are these adverse mortality tendencies reflected in our total population? In estimating the probable increase in the entire country, many factors must be considered, the discussion of which would consume many hours.

The rate of increase in Massachusetts and New Jersey (21 per cent) doubtless approximates that of all of the populous States of the East. This rate would, however, be reduced if merged with the rate of increase for the agricultural population of the Western and Northwestern States. On the other hand, this reduction would be largely, if not totally, neutralized by the heavy urban and rural mortality in the South.

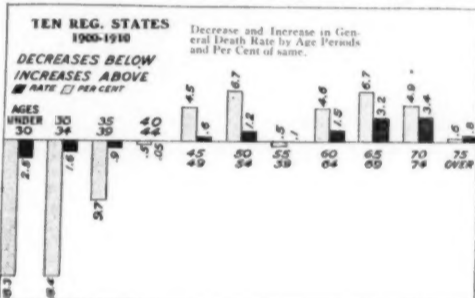
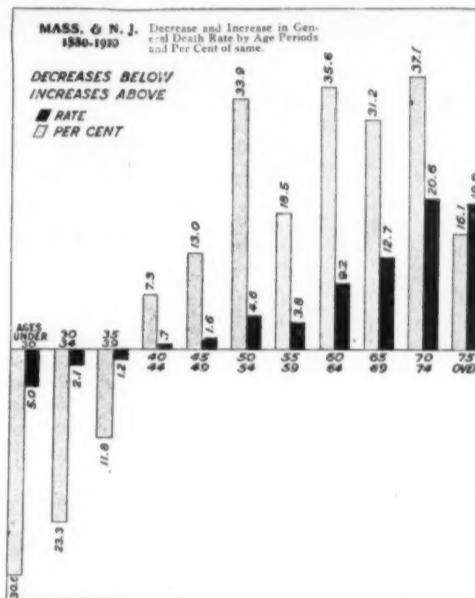
My own belief is that in the past 30 years the mortality rate of our entire population in the group above age 40 has increased at least 20 per cent, and that the increase is undoubtedly still going on. I am, therefore, in accord with Mr. John K. Gore's opinion, that while the average length of life has advanced, the extreme span of life has not done so,—in fact, the indications are that it has been shortened.

It seems that we have failed to adapt ourselves to the sudden increase in the life strain, due to our complex and rapidly changing conditions of life.

The increase in American life strain is not alone due to the high pressure of modern existence. One element of our population is undoubtedly deteriorating from overstrain, due to excessive physical and mental exertion. But we also have a large group who are suffering from the excesses of indolence and physical inactivity. The benefit of exercise from walking has alone been seriously curtailed by the advent of cheap transportation in our cities and towns. The tendency of most modern inventions is to reduce physical exercise and to encourage obesity. Many thousands of our industrial people are now watching or feeding machinery at the cost of slight physical exertion; while to accomplish the same output in former

years, considerable physical activity was required. Even our farmers ride in sulky plows over the same fields in which their fathers followed the furrow on foot. The automobile has brought many people into the open air, but it has added to the nerve strain, and encourages physical inertia, overeating and drinking, all of which promote physical degeneration. These are just as important factors in the increasing American life strain as excessive mental and physical exertion.

Our expanding knowledge of medicine, especially in the field of prevention, and the adoption of more healthful habits of life by some of our people have undoubtedly prolonged many lives in middle life and old age, as well as in the younger ages. This gain, however, is obscured in the older ages by the increasing premature mortality indicated by the statistics, which would seem to result from the unhealthy habits of a still larger group of our people.



But let us assume that the degenerative mortality rate has increased but 5 or 10 per cent; let us assume that it shows no increase at all, or that it actually shows a slight decrease, would not the urgent need for reducing this misery and life waste still exist?

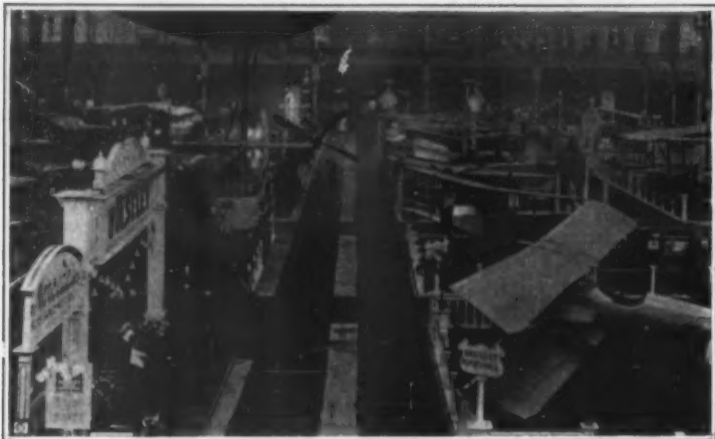
And it is life waste for I am told by physicians that fully 50, and perhaps 60 per cent of the deaths from degenerative affections could be prevented, or postponed for many years, by the adoption of ordinary and well-known personal and community health precautions, which include periodical health examinations to detect the existence of these diseases in the early stages, when in many instances they will respond to medical skill.

Because it is a difficult and a perpetual task to teach our people to adopt these rational and economical practices offers no reason why the task should not be taken up and pushed with constantly increasing vigor.

The gain from such an educational movement would not alone be in extending our years here below, but in the prevention of a vast amount of suffering, poverty, immortality, crime and financial loss which precede and follow this life waste.

There can be no better way to promote the present and future welfare of our race than by waging vigorous and continuous war against diseases of the degenerative class, which are prematurely blasting and destroying so many valuable American lives.

"Automobile Knee" is the Latest.—We have had the "automobile eye" and the "automobile heart" and altogether the automobile has acquired quite a little pathology all its own. Now comes the "automobile knee;" it has been discovered by an American practitioner. An increase in adipose tissue, due to lack of exercise, with a corresponding decrease in the muscular power of the legs is said to be the direct cause of the trouble. It results in a slackness of the knee ligaments which causes a predisposition to strains.



View of Exhibition Showing Government Dirigible "Delta" on Left and Breguet and Roe Biplanes and Nieuport Monoplane on Right.



View Showing Porter Helicopter in Left Foreground and the War Office Biplane "BE₂" in the Right. Next to Latter is Martin Handasyde Monoplane.

The Aeronautic Show at Olympia

Description of Some of the Principal Machines Exhibited

By Stanley Yale Beach

THE Aeronautic Show at Olympia, in London, which took place last month, was the first big exhibition since the show in the Grand Palais, Paris, last October. Two thirds of the machines exhibited were of English design and manufacture, and in finish and workman-

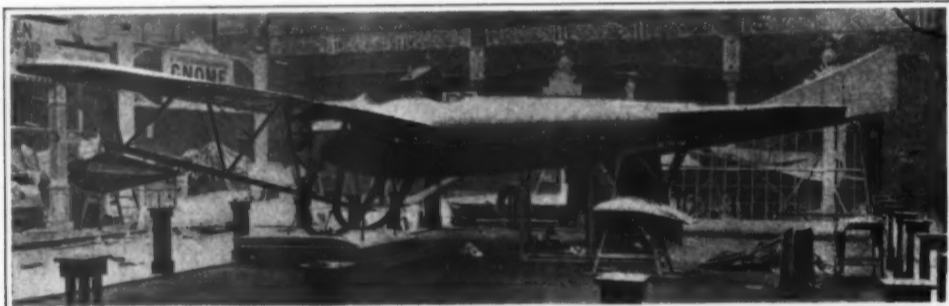
was mounted upon the upper member of a triangular fuselage, and so fitted that it can readily be removed if desired. The Colt gun was mounted above the front end of the car, with seats for the gunner and his helper just back of it. The gun had a range of

the amount of fuel in the service tank. The machine had wide skids made up of two pieces of wood connected together by cross-members and by metal at the front. Wheels having twin rims and tires were placed in the middle of each skid, the skid being supported from the wheel hub by means of leaf-springs and hangers. The chord of the surfaces was 6 feet, and the spread of the upper plane 42 feet as against 23 feet of the lower. The total supporting surface was 435 square feet. The planes were built with the same cross section as the Eiffel experimental plane "No. 8." They could be quickly detached and laid alongside the 7½-foot center section for towing over the road. The tail was made up of a single flat surface containing 50 square feet, while the elevator flaps had an area of 25 square feet, and the vertical rudder one of 23 square feet. The weight of this machine without passengers or fuel was 2,100 pounds. It was designed to carry 750 pounds useful load and is expected to make 50 to 70 miles an hour when fitted with a 120 horse-power engine.

A second war biplane was the Vickers. This is a biplane with a Maxim gun which can be swung through 120 degrees in either a vertical or horizontal plane.

Of the two seats, the gunner occupies the forward one and can draw within reach a box with 1,500 rounds of ammunition. This box is mounted on wires and ordinarily rests at or near the center of gravity of the machine. It can be moved back and forth by the gunner with ease. The pilot sits immediately behind the gunner and the motor is placed back of the pilot, with the propeller mounted upon its cam shaft so that it turns at half the speed of the engine. This machine is fitted with the new Wolsley 60-80 horse-power, air-cooled motor with water-cooled heads, of the 8-cylinder, V type. The feature of this machine is the fitting of a duplicate control for the gunner in case any accident befalls the pilot. The body of the aeroplane is of steel tubing covered with sheet Duralumin. It has a stream line form. The machine is a staggered biplane, the upper plane being placed somewhat in advance of the lower. Stranded steel cable is used for the guys in place of piano wire, the latter being used only in the body. The planes can be taken off quickly, leaving the center section of each no wider than the body. In the interior of the center section of the upper plane is a small gasoline tank from which fuel is fed by gravity to the carburetor. The gasoline is forced to this tank from the main tank in the body by pressure, the pipes for this purpose being concealed in the hollow spars. No oil tank is needed, as sufficient oil is carried in the base of the motor for a 6-hour flight.

An improved military tractor biplane for scouting was the two-seater "Bristol." This machine had an over-all length of 28 feet, a spread of 37 feet, and a supporting surface of 440 square feet. Its weight empty, was 940 pounds and it will carry a useful load of 880 pounds. With a speed of 60 miles per hour, it has a radius of action of 120 miles, four hours' flight. It is fitted with a non-lifting tail consisting of the usual fixed surface and winged elevator. A balanced vertical rudder is located in front of the elevator, which is at the extreme end of the regular monoplane body. The chassis of this machine has several novel features. Four disk wheels are located at the four corners, one



By Courtesy of The Car

Side View of British-built Deperdussin Hydro-monoplane.

Note the triangular trussing below the wing and floats upon which body is mounted. The entire absence of guys above the wings is also a noteworthy feature.

ship they are quite on a par with the aeroplanes turned out in France.

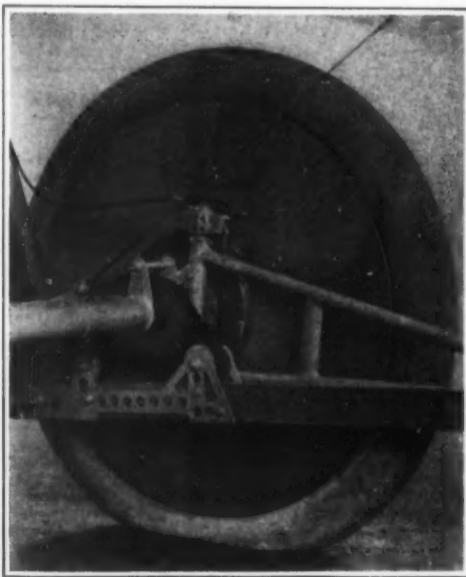
The machines that were exhibited were of two general classes, namely, land machines and hydro-aeroplanes. Six out of the twenty-four aeroplanes shown were of the latter type. The land machines were divided into military aeroplanes and aeroplanes for sport. As regards the former, there were several that were built not merely for scouting purposes, but rather for fighting in the air, since they were provided with rapid-fire guns capable of doing considerable damage, especially to dirigibles. There were fifteen biplanes and nine monoplanes on exhibition.

Several of the photographs reproduced herewith give a general idea of the exhibition. As will be seen, the government dirigible "Delta" occupied a central position, while the War Office aeroplane "BE₂" can be seen on the right of one of the illustrations, at the top of this page. The huge Cody biplane, which has flown over 7,000 miles and which was the winner of the Military Competition last August, was also exhibited by the War Office. It has shown a speed of 72 miles per hour and a climbing ability of 300 feet per minute.

Two of our illustrations show the Breguet military biplane in the foreground, while still another picture shows a Caudron biplane in the right corner, with a Farman biplane behind it, and a Martin Handasyde monoplane next to the Bristol.

Coming now to the war machines, the huge biplane fitted with a quick-firing gun, exhibited by Grahame-White, was one of the most notable. This machine is shown in one of our illustrations. It was provided with a 90 horse-power Austro-Daimler motor, which was mounted at the front of the car, just back of the radiator. The motor was fitted with a muffler, making conversation possible between the pilot and passenger. A shaft running back from the motor was arranged to drive the propeller by means of sprockets and chain, the gear reduction being 14 to 23. Arrangements were made for ½-inch take-up on the chain. The propeller

180 degrees in a horizontal plane, and 50 degrees in a vertical plane. The pilot was placed back of the gunner, and controlled the machine by a vertical lever and foot tiller, as usual. Below the pilot's feet was a large gasoline tank having enough capacity for a 6-hour flight. The fuel was forced by the exhaust pressure from the engine to a small tank in front and above the level of the carburetor, so that the final feed was by gravity. A special gage was arranged to indicate



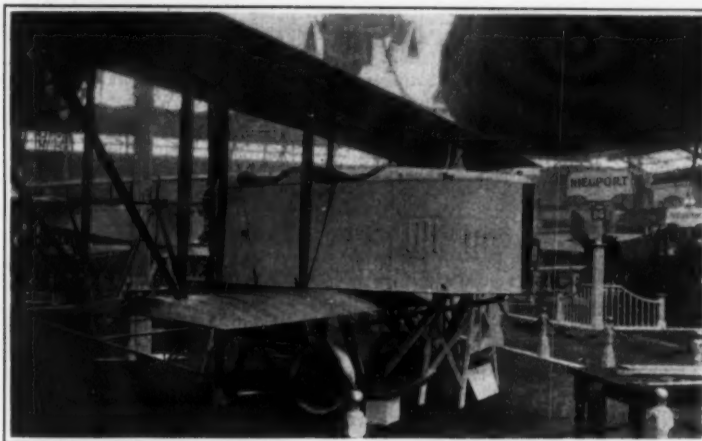
By Courtesy of Aeromarine

Detail of Bristol Biplane.

Note disk wheel fitted with band brake, and method of suspending frame of undercarriage from axle by elastic cord.



The Motor Stands are Seen on the Left, with the Caudron and Farman Biplanes in the Foreground on the Right.

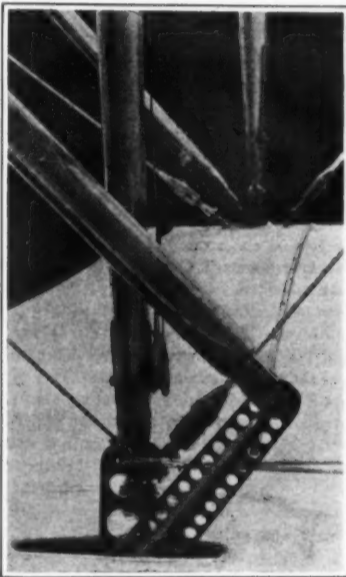


Grahame-White's New War Biplane, Showing Maxim Gun and Radiator in Front and Propeller at Rear of Body.

at each corner of a rectangular frame to which the body is connected by four inclined struts. The rear wheels are the larger and carry most of the weight. The rectangular frame is suspended from their axle by means of elastic cords in the manner shown in the detailed photograph reproduced on this page. Band brakes are fitted to each of these rear wheels for the purpose of making a quick stop as well as for steering when the machine is running slowly over the ground. By means of separate levers the brakes can be applied individually for steering. The wheels can be readily removed and a float fitted if it is desired to convert this machine into a hydro-aeroplane.

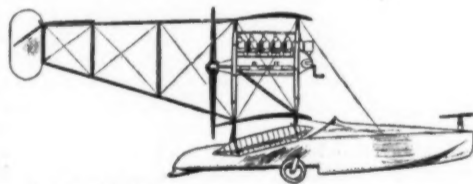
The chief novelty in construction was shown in the British-built Deperdussin hydro-monoplane, shown in one of our illustrations. This novelty consisted in dispensing with all the usual guys, and bracing the wings on their under side with strong triangular trusses of steel tubing. This method of wing bracing is said to be much stronger than the usual one with guys, the consequence being that a heavy landing will not deform the wings. Compression of the wing spars is greatly minimized, a very important point, and the time taken to assemble or dismantle is lessened. The total weight of the steel tubing for trussing the wings is but 35 pounds, so this system is no heavier than the usual steel cable guys. The wings of this machine are novel in that only the part back of the rear spar is flexible. This warping portion of each wing is extremely flexible and should not deteriorate with use. The wings are wider at the tips than at the shoulder. They are covered with a special fabric having threads arranged in bunches and running at right angles to each other, forming squares. The perforation of one or more of these squares by bullets would not harm the wing. The body of this machine is built in lengthwise halves instead of being in a single piece as in the French *monocoque*. The torpedo shape is identical, however. Each half is constructed by laying narrow strips of tulip wood over a form. The strips are in three layers, those of the first two layers running at right angles to each other. Two coverings of strong fabric are applied to the outside, so that a stiff integral shell is formed that requires no internal bracing. The tail surface is slightly cambered so as to lift about 80 pounds. A small cambered float is provided beneath the tail. The single wide float in front is flat bottomed. It consists of an ash frame covered with three-ply wood and canvas. Both

floats support the body by means of oval frames. In the case of the land machine, the axle of the two disk wheels is attached to the large oval frame by elastics. The passenger sits in front of the pilot and has a good



By Courtesy of Aeronautics
New Method of Warping Wings on Grahame-White's Biplane.

The warping is accomplished by means of levers, thus dispensing with cables and pulleys.



By Courtesy of Flight
Side View of Sopwith Flying Boat.
A biplane mounted upon a single-step hydroplane hull. Note front elevator mounted on nose of hull.

view downward, as the wings are cut away for the purpose. The main fuel tank is flush with the floor between the two seats. The gasoline is fed by a small automatic pump to the service tank above and just behind the motor. The passenger has in front of him gauge glasses showing whether or not the fuel is flowing. Should these break, the gasoline can be shut off and danger from fire avoided. The dimensions, etc., of this hydro-monoplane are: Length, 26 feet; spread, 43 feet; area, 330 square feet; weight, empty, 1,160 pounds; useful load, 730 pounds; speed, 63 miles per hour; motor, 100 horse-power circular Anzani.

The chief attempt at improving the hydro-aeroplane seen at the show was the flying boat of T. O. M. Sopwith. Mr. Sopwith has simply mounted a biplane upon a 21-foot hydroplane having a single step and a beam of 4 feet, sufficient to seat the pilot and passenger side by side. This boat was built of cedar by Saunders after his ingenious method of sewing two layers of wood together by means of copper wire and attaching them in like manner to the skeleton of the hull. These layers are very thin and make the whole boat weigh only 180 pounds. The step is placed 12 feet from the bow and has a depth of between 3 and 4 inches. Two wheels are arranged on an axle in such a way that they can be raised out of action when the boat is operating on the water, and dropped down into place when a landing is to be made upon *terra firma*.

The biplane mounted upon this hull has a spread of 11 feet with a chord of 5½ feet. Its total area is 422 square feet. The length over all of the machine is 32 feet, and its weight empty 1,200 pounds. A 90 horse-power, 6-cylinder Austro-Daimler motor drives this machine at a speed of 65 miles an hour, and when carrying two persons and a load of fuel, the weight carried per square foot is 4 pounds. The struts and main spars are made of hollow built-up sections using ash and spruce for the center and outside respectively. The ribs are made of a very elastic wood and it is possible to twist them to an angle of over 90 degrees without having them lose their shape. The tail of the machine, rectangular in shape and containing 22 square feet of surface, is made up largely of steel tubing, as are also the tips and trailing edge of the main planes. The result in the latter case is that the camber is maintained at all times and good efficiency is obtained. A front elevator is mounted on top of the bow of the boat and acts in conjunction with the one at the rear.

Continuous Rail for Chicago Street Traction

The Story of a Rush Order

THE Man from London appeared before the Board of Supervising Engineers Chicago Traction on the 28th of July, 1911, and offered to lay before the end of the year ten miles of continuous rail, which had been tried out in England and France.

"Impossible," said the Board. "We have contracted for all the work we intend to do this year; and we have no such mileage to build." "Good," said the Man from London, "let's discuss details."

On the 31st of July, on his way home he telegraphed from Pittsburgh, asking if the Board would do six miles. Promptly the answer came back, "No, two miles is all we can do." By the time he reached New York, a compromise had been made; and four miles had been agreed to.

On the 10th of August he was back in Chicago; and on the 17th a draft agreement, between the Board and

the English Company he represented, was in his pocket as he made his way to the "Twentieth Century" train.

Hurriedly reading through the "whereases" and the "now, therefore," he found that the Board wished him to guarantee the delivery of a machine from England by the 20th of October; to guarantee delivery of one thousand tons of rails from the rolling mills by that time, and apparently to guarantee that the weather in Chicago after the 20th of October would be suitable for the carrying out of the contract. "And, furthermore," he was to guarantee that the inventor would come over from England to do the work within a prescribed and limited time.

From Cleveland he telegraphed his acceptance of the terms of the contract; and the following morning in New York called upon the president of one of our

great steel firms, to whom he had previously presented a letter of introduction.

"I have an unsigned contract in my pocket," said the Man from London, "which requires one thousand tons of steel rail of an entirely new design to be manufactured and delivered in the city of Chicago by the 20th day of October. I have been told by two or three rail manufacturers that this is impossible; and I have, therefore, come to you to have the thing done."

"Have you seen the manager," said the president. "Yes," said the Man from London. "He says that commercially it is impossible, but physically it is within the range of possibility."

"Good," said the president. "We are in business to do the commercially impossible; and it is our policy to encourage any advance in the art connected with our business."

Private wires and long-distance telephones were immediately put into requisition. "Hello," said the president, "there is a Man from London in my office who says you can do the commercially impossible—talk to him." Taking up the telephone, the Man from London said: "Mr. Manager, I want one thousand tons of a new section of rail delivered in the city of Chicago on the 20th day of October." "Be in Pittsburgh tomorrow morning," said the Manager.

"Mr. President," said the Man from London before taking his leave, "the contract with the Chicago Board of Supervising Engineers has not yet been accepted by the English Company, and until it is accepted, the Board will not sign the contract to buy rails, and I am asking you to go ahead without any contract or guarantee, except my personal belief that these contracts will be executed in due course." "You have faith in your enterprise," replied the President, "your friends have faith in you, and we have faith in your friends—go ahead."

Next morning a meeting of all the heads of departments of the steel company was held in Pittsburgh; and the specifications for the new rails discussed in all details. These details included the chemical composition of the steel, its degree of hardness, the exact dimensions of each portion of the rail, and all the hundred and one items which enter into an engineer's specifications for the manufacture of high-grade steel rails from the time when the cast ingots are rolled into blooms, until the finished rails are placed upon the railway cars for shipment.

Returning to New York, the Man from London established himself close to the land end of one of the submarine cables and got into touch with the English company. "Alter your machine to operate upon the rails that are used in Chicago, and then ship it with the inventor so as to arrive in Chicago in time to be at work on the morning of the 20th of October." "You are trying to do the impossible," was flashed back; "no rolling-mill can turn out your rails within the time, and, furthermore, we have no drawing of the Chicago section." Anticipating the latter difficulty, the principal assistant engineer to the Chicago Board, had worked out a plan by which an engineer's drawing could be transmitted by cable. And the Man from London so transmitted the drawing, and ended his cable dispatch with the words "Take care of your end and we will hold up ours."

Daily wires reported progress of the work at Leeds, Yorkshire, in getting the machine ready. Unexpected delay occurred; a steel casting was lost in transit and a duplicate had to be transported by passenger train. The train to take the machine to the dock had to be held up for an hour, and when it finally reached the steamer's side at Liverpool, the captain of the ship refused to take it on board on account of the weight and size of the packages, one of them weighing over three tons, and the total weight amounting to over twelve tons. From Liverpool was cabled "Impossible to ship in time." The Man from London dropped in at the office of an express company, made arrangements with them in about two minutes, and answered back, "Deliver the machine to the express company's agent to be shipped by express, in bond, to Chicago."

The machine arrived in Boston on Columbus Day, and nothing could be done with it until the following morning, when it was put upon the cars and started on its way to Chicago. On the same day the inventor arrived in New York. The following day he was in Pittsburgh; and on Sunday, the 15th of October, in Chicago.

Meanwhile, the rolling-mills had cast the rolls; transferred the design from the drawings to the rolls; cut them; put them in the mill; and were completing the rolling. Some of the rails had already gone forward and cars were being loaded with the balance. The first shipment arrived in Chicago on the 17th of October, and the whole shipment was made with time to spare, establishing a world time-record in rolling-mill practice.

On Monday morning, the 16th of October, 1911, the car containing the machine arrived at the Twelfth Street Yards of the Michigan Central Railroad. "How long will it take to get delivery of that car," was asked of the express company. "It usually takes a week to clear from the customs and to transfer." "I want that car to-morrow morning," said the Man from London. "Impossible," said the express company. "My friend," said the Man from London, "I have been doing the 'impossible' every day for the last two months. Let's go on with the good work. Who has charge of that car?" "The yardmaster." "Hello, yardmaster." You have a car in your yard addressed to the Chicago City Railway Company. How soon can you get it around to the Belt Line?" "Not until after we get the customs' permit."

The Man from London hastened to the Federal Building, paid the duties, and asked for his permit. "Come in day after to-morrow," said the Custom House offi-

cial. "I want it to-day," said the Man from London. "Impossible," said the official. "Let's discuss it," said the Man from London. Said the official, "Your permit has got to take its turn; it goes to the bottom of the file. When we get to it, we will sign it, and hand it to you. Everybody else is in a hurry and you must wait your turn."

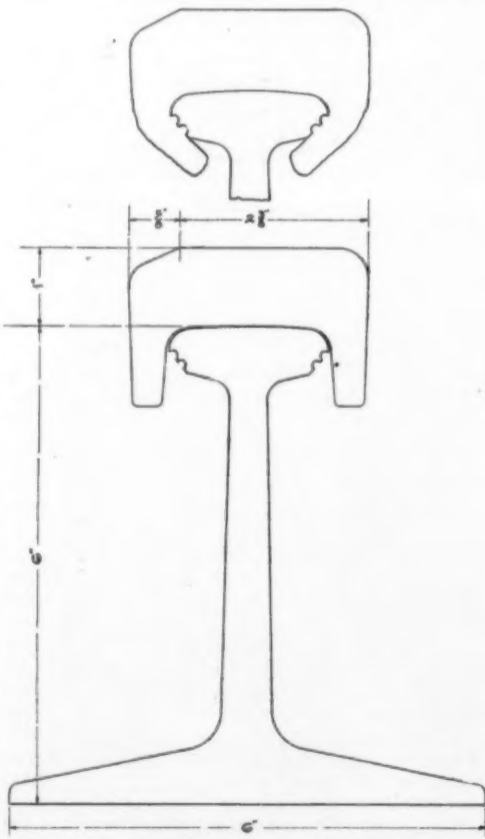


The Steam Machine That was Sent from Leeds to Chicago by Express, in Operation on South Halsted Street With the Inventor on the Footboard.

The Man from London told his story, and suggested that a way out of the difficulty might be found if a half dozen men were put on that file, and the bottom reached in a couple of hours. The officials entered into the spirit of the game; the permit was delivered to the Michigan Central Company at half past four; and the car moved out to Kensington that night.

Through the courtesy of the Chief United States Appraiser, and the Chief Inspector of Customs, an appraiser and an inspector were promised as soon as the car was ready to be examined. At three o'clock on Tuesday the car was sighted, and at three-thirty it arrived at its destination in the yards of the Chicago City Railway Company at Seventy-ninth Street and Vincennes Avenue. By four o'clock the appraiser and examiner had been taken out to the yards in an automobile; and at five o'clock the machine had "passed the customs," and unloading had begun.

Feverish activity prevailed at the car-shops during the next forty-eight hours. The twenty different cases in which the various parts of the machine had been packed were opened; the machine assembled; and on



Section Through Continuous Rail, Showing How the Wearing Surface is Crimped on.

the morning of the 20th of October a letter was delivered to the chairman of the Board of Supervising Engineers, to the following effect: "We beg to advise that the inventor, the machine and the rails are in Chicago; and that the weather is fine."

The machine which was in this way brought to Chicago was operated on South Halsted Street. Its mission is to "crimp" the head section on the base section of a compound rail, thereby forming a solid rail which when worn out need not be removed in its entirety from the street, but can have its head cut off and a new one replaced, with a great saving of time and cost.

It was not until a week after the machine was ready to start that the rails were in position for work to be begun in South Halsted Street. Meanwhile permission had to be sought from the city officials to use the boiler on the public streets; to move the machine over the streets; and to use the fire-hydrants. The boiler also had to be inspected. When all these formalities had been gone through, and the machine was ready to start work, the Man from London said to the inventor, "It's now up to you."

The inventor got busy. The fire in the boiler was lighted; steam was gotten up; and the machine was just about to start when the City Inspector stepped forward and said, "This machine must stop work at once." It then appeared that the Commissioner of Public Works should have been consulted; and after this formality had been complied with, the machine was at last put to work.

Then an unexpected difficulty presented itself. The English machine had been built to crimp a much lighter section of rail with soft steel flanges only $\frac{3}{8}$ inch thick. And when it had been altered to crimp the heavier Chicago rails, with flanges of hard steel $\frac{7}{16}$ inch thick, it was thought that this was the limit of the machine's capabilities. It was found, however, when work was started, that the machine would be called upon to crimp flanges over $\frac{1}{2}$ inch thick; and further alterations had to be at once made in order to meet these new conditions.

When the machine appeared upon the streets, the engineers, who came from far and near to see it in operation, called it "The Joke," so frail did it appear in comparison with the heavy work it was doing.

As was to have been expected, many break-downs occurred and the inventor saw his beautiful machine suffering in every part: First, a shaft broke; then a lazy-wheel; then a pin; but as each break occurred it was repaired, and "The Joke" continued slowly, but surely to crimp the rails.

In order to expedite matters, it was determined to try night work—the inventor taking the day shift, and his assistant working the machine at night. The second night after this experiment, while the inventor and the Man from London were conferring with a representative of the steel company, a call came over the telephone to the effect that the machine would have to stop work as they were running out of fuel. The trio started for South Halsted Street in a taxi to see what could be done, and arrived there about midnight. They found no fuel was left for the boiler; and that the nearest supply was about a half mile away, with nothing on hand bigger than a bucket in which to carry it. A search was started for men and wheelbarrows. In the neighborhood of South Halsted Street and Fortieth Street, one of the railway company's yards is situated. Entering the gates, the fuel-seekers saw great heaps of paving stone, sand, and other railway material, into which they plunged, when they suddenly found themselves in the midst of a band of twenty rough-looking Italians with knives in their hands seated around a bon-fire. This blood-thirsty looking band were not brigands, although they certainly looked the part, but only night-laborers taking their supper. The foreman yielded to gentle persuasion and detailed three of his gang with wheelbarrows to cart the fuel up to the machine—and steam was kept up that night. Including the price of the taxi and the tips to the men, those six barrows of fuel each cost \$1.50 to be moved four blocks.

Another accident threatened to stop the machine when a steam-joint blew out, and it looked as though the work would have to be discontinued for twenty-four hours; but friendly help was procured from the engineer of a big brewery down on South Halsted Street, and a couple of hours effected the necessary repairs. The inventor grimly stuck to the job in spite of all difficulties, but in the end work had to be suspended on account of the weather. November, 1911, was the coldest in twenty years. It was not so bad up to the 11th of November; and on that day, which was a Saturday, the thermometer rose to 74 degrees. Then the trouble began. That night a gale blew up which reached a velocity of 48 miles an hour; snow fell, and before midnight it was freezing. Sunday night the thermometer fell to 12 degrees, which was the lowest temperature for the first half of November since the records have been kept in Chicago. So, after complet-

ing a mile of road from Thirty-first Street to Thirty-ninth Street, upon which the cars began running on the 24th of November, 1911, it was determined to do no more work for a year—when the Man from London came back to Chicago with an American-built machine operated by electricity. This machine has recently finished crimping a mile of track on Forty-seventh Street, west of Pauline Street, and two miles of track

for the Chicago Railways Company on West Sixteenth Street, near South Fortieth Avenue.

It is well known to railway men that the soil of Chicago does not offer an ideal foundation for track-laying, and wet weather seriously increases the difficulties. It was when the "Joke" was working in South Halstead Street during a snowstorm, that the policeman said to the foreman, "That's a bad foundation for

a job like that." "Faith," said the foreman, "those rails are laid on the best of all foundations—clean grit."

But the "Joker" behind the "Joke" was betrayed by the same foreman a few days later when he was asked if he did not think the man from London was very much of "a live wire" for an Englishman. "Englishman!" said he, "not a bit of it; the Man from London was born in the Seventh Ward, New York city."

The Bacteriology of Ice

The Danger of Infection from Natural Ice Not Very Great

By Edwin O. Jordan, Ph.D., Professor of Bacteriology, University of Chicago

The principal disease of man in the United States due to swallowing disease germs is probably typhoid fever. From the standpoint of typhoid fever infection natural ice possesses two advantages over natural water and three over natural milk. Milk ordinarily is consumed in the household while in a fresh state, and hence if infection is present it is of recent origin, and therefore peculiarly dangerous. In milk, moreover, multiplication of typhoid bacilli may occur during transit. In ice bacteria never multiply from the day the ice is formed to the day it is delivered to the consumer. Ice is less likely than water to convey typhoid infection, first because the act of freezing destroys a large percentage of all bacteria contained, including any disease germs that may be present, and second because of the length of the period usually elapsing between freezing and use. The longer water and ice are stored, the safer they become; natural ice is practically always stored for a considerable time, usually for several weeks, often for many months. As compared with water then, ice has been subjected to a more or less complete sterilization by freezing, and any micro-organisms that survive the freezing process are still further reduced in numbers by a long-continued storage.

The significant points in the bacteriology of ice are, therefore, first the effects of the freezing process upon bacteria, second the effects of storage. Experimenters have found that freezing destroys within a few hours a large percentage of typhoid bacilli. This is greater in the cases of some races of bacilli than others, but is always considerable. Sedgwick and Winslow found in one experiment that only 41 per cent were alive 15 minutes and only 22 per cent 6 hours after freezing. Earlier investigations were imperfect and created erroneous impressions in so far as they neglected the quantitative aspect of the subject. The circumstance that when millions of typhoid bacilli were added to a small quantity of water in a test-tube some bacilli might survive for several months after freezing was so far from representing natural conditions that it had little practical value. Sedgwick and Winslow, Park and others cleared this matter up and showed that the great majority of typhoid bacilli perish within a short time. All investigators are now agreed that three weeks after freezing less than 1 per cent and probably less than one half of 1 per cent remain alive.

We know that these observations in the laboratory fairly represent actual natural conditions, since bacterial analyses of natural ice made during the harvesting of the ice crop give similar results. Examinations of natural ice taken freshly from the ice fields were made some years ago by the writer under the auspices of the State Board of Health of Massachusetts and showed without exception a much smaller number of bacteria in the ice than in the samples of water collected at the point where the ice was formed. The following table shows some typical results:

Source.	Bacteria in Water.	Bacteria in Freshly Formed Ice.
Buckton, Factory Pond.....	111	3
Brighton, Hollis Pond.....	20,000	702
Concord, Warner's Pond.....	1,290	0
Dorchester, King's Pond.....	412	3
Freetown, Forge Pond.....	224	11
Gardner, Crystal Lake.....	4,004	5
Holyoke, Connecticut River.....	281	22
Jamaica Pond.....	147	1
Lawrence, Merrimac River.....	274	6
Lowell, Merrimac River.....	277	1
Marlborough, Lake William.....	4	0
Millbury, Blackstone River.....	3,762	241
Newton, Hammond's Pond.....	115	5
Newton, Pearl Lake.....	638	20
Pittsfield, Silver Lake.....	98	4
Turner's Falls, Connecticut River	1,456	25
Waltham, Charles River.....	222	2
Woburn, Horn Pond.....	1,342	0

It will be noticed that freezing accomplishes in many cases about the same percentage reduction of bacteria as is effected by slow sand filtration.

Merrimac River, Lawrence Filter, Intake of filter, 6,500 bacteria per cubic centimeter; Outlet, 105 bacteria per cubic centimeter.

Hudson River, Albany Filter, 47,800 bacteria per cubic centimeter; Outlet, 470 bacteria per cubic centimeter.

In connection with the examination of natural ice, there is one point upon which I should like to digress for a moment. This is as to the method of analysis to be adopted in order to obtain definite information regarding the character of ice. Whatever the merits of chemical methods in the sanitary examination of water, there can be no doubt that they are of little value in determining the quality of natural ice. The essential disease-producing elements in polluted water are not chemical substances but living micro-organisms. The effect of storage, for example, upon germ vitality cannot in any way be determined by chemical analyses but only by bacteriological tests. If, therefore, bacterial examination of natural ice is made, chemical analysis is not necessary, is indeed even useless.

To the initial purification brought about by freezing is added the still further reduction of bacterial life through storage. The time-factor is the most important element in producing the death of ordinary pathogenic bacteria outside the body. The eminent English water bacteriologist, Houston, has recently shown that simple storage of water in reservoirs reduces the number of bacteria of all sorts, including those of fecal origin, and also devitalizes the microbes of water-borne diseases (for example, the typhoid bacillus and the cholera vibrio). He concludes that, "An adequately stored water is to be regarded as a 'safe' water and the 'safety change' which has occurred in a stored water can be recognized by appropriate tests." And further: "The habitual use of stored water would lighten the grave responsibilities of the Water Board as regards the safety of the London water supply, and would tend to create a sense of security among those who watch over the health of the Metropolis." Natural ice is habitually stored for a considerable period and this fact materially increases its safety from the public health standpoint. After three or four months the danger from ice cut from even highly polluted water would be very slight, and after six months' storage would be practically negligible.

None of the above statements must be taken as indicating that in my opinion it is safe to resort to contaminated water sources for the harvesting of ice destined to come into contact with food. If sewage pollution is so great that solid masses of infectious material may be frozen into the ice, then the life of typhoid bacilli may be much longer than indicated in any of the experiments cited. In the same way if the surface of the ice field is overflowed during harvesting in such a manner that dangerous material is included in the newly formed ice, the possibility that the ice may convey infection cannot be overlooked. The few instances—numbered on the fingers of one hand—where natural ice has been held to be responsible for the transmission of disease are cases of this character.

In this respect artificial ice must stand on the same footing as natural ice. If a contaminated water supply is used in the manufacture of artificial ice the danger to health is just as great as in the case of natural ice cut from a similarly contaminated source—in fact, it may be somewhat greater owing to the shorter period of storage to which artificial ice is subjected.

Electrification of Benzene by Friction*

PROF. F. DOLEZALEK, of Charlottenburg, has experimented on the danger of electric sparking arising when benzene and ether are being passed through coils and pipes. The general arrangement was the same in all the tests, and was probably adopted on the suggestion of the firm. The benzene or ether, we see from the *Chemische Industrie* of January 15th, 1913, was contained in a brass cylinder, into the bottom of which pipes of various metals could be screwed. The outflow took

place under the pressure of carbon dioxide, and was regulated in such a way that the rate of flow of the liquid through the pipe could be varied between less than 1 meter and more than 4 meters per second. From the open end of the pipe the liquid jet fell into another tank, insulated and joined to an electrostatic voltmeter.

The particular object of the test was to investigate whether the friction of the liquid in the pipe would charge it to such an extent that the explosive vapors collecting over the liquid in the tank might be ignited by spontaneous sparks. Attempts to measure the potential of the liquid in the tank by inserting an exploring electrode into the tank-liquid were unsuccessful, on account of the friction on the electrode. The metallic pipes tested were of iron, brass, copper, lead, and aluminium, used as supplied by the trade; they were earthed in the experiments. It was expected that at slow rates of flow no frictional electricity would be generated, because a skin of liquid would then adhere to the pipe wall; there would thus be internal friction only, between liquid and liquid of the same kind, and hence no generation of electricity. With more rapid flow, however, external friction between liquid and metal would arise, and electricity be generated. This assumption was proved to be correct, and the potentials set up gave regular curves when plotted against the linear rates of flow. But there were, of course, differences depending upon the different metals and the surface conditions. Crude benzene (containing 90 per cent of pure benzene) became electro-negative against iron, copper, and aluminium, but positive against lead and brass; the highest potentials of more than 3,000 volts were observed in iron, the lowest in aluminium. That brass and copper should differ as to the sign of the charge is interesting; zinc was not tried apparently, but a brass which was unelectrified, i. e., did not become electrified, was actually prepared. The peculiarity is not of importance, however, though it might be utilized analytically; for it was observed that pure benzene took a negative charge, both in copper and brass, but that a slight addition of impure benzene (1 per mille) reduced the potential in brass again to zero. Iron, again, gave the highest potential to pure benzene. Similar results were obtained with ether. Qualitatively dehydrated ether (distilled over sodium metal) and moist ether behaved in the same way; quantitatively there were great differences, and dry ether took, even at slow rates of motion, very much higher potentials than moist ether.

In all these experiments the pipes were used as supplied, and the walls were therefore more or less covered with an oxide film. When a copper pipe was more completely oxidized by heating it while an air current was passed through it, the negative charge which it imparted to flowing benzene was increased; when the oxide was then reduced by means of hydrogen, so that the copper looked bright and metallic, the benzene-flow test gave a positive charge. In use the pipes would always be slightly oxidized on their surfaces, of course. In pipes made of insulators, glass and porcelain, the potentials were always very low, about 100 volts, because the one of the two opposite charges produced by the friction could not be eliminated by earthing the pipe, which had been done in the case of the metals, as mentioned. High charges were, however, observed again when metallic taps were inserted into glass tubes. Insulation tests of the liquids demonstrated that benzene was a much better insulator than ether; there is hence much greater danger with benzene than with ether by the spreading of the charged layer of liquid. On the other hand, the atomizing of ether, produced by pumping the liquid and some air from one vessel into another, electrified the ether to much higher potentials than benzene, so that greater danger would attach to ether in that case. The practical conclusion to be drawn is that the flow of benzene and ether through pipes, and especially also through taps, should be kept at a slow rate, say less than half a meter per second in iron, at any rate, so that the potentials may not much exceed 300 volts; this is the lowest potential at which a spark would cause an explosion.

* Reproduced from *Engineering*.

Peroxides and Per-Salts—II

Their Preparation, Properties and Uses in the Arts and Industries

By A. S. Neumark

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 1942, page 188, March 22, 1913

METALLIC PEROXIDES AND PER-SALTS.

IN spite of the many uses in the arts and industry which have been found for hydrogen peroxide, this product possesses certain disadvantages which preclude its more general use, such as its relatively high cost and its unstableness in aqueous solution. As hydrogen peroxide is put on the market almost exclusively as a 3 per cent solution, the cost of the product is greatly influenced by the carriage from one place to another. What chemists have long been looking for was a solid substance which possesses all the properties of H_2O_2 . Such substances have been found in the alkali, earth alkali and allied peroxides and in the salts of peroxides with various acids and per acids. These "per-salts," as they have been named, must, however, not be confounded with such compounds as permanganates, perchlorates and the like.

Metallic peroxides are compounds in which the hydrogen of H_2O_2 has been replaced by metals, and which are readily decomposed with the liberation of H_2O_2 or oxygen in the nascent state. In this way the entire oxygen-content of the peroxide is quickly made available. The different peroxides vary considerably in their stability, their solubility, and in their ease of decomposition in solution. According to its acid nature, H_2O_2 forms salts with bases (such as the hydrates of alkalies and earth alkalies) which may be regarded as salts of hydrogen peroxide. With acids it forms per-acids; thus by the action of concentrated sulphuric acid on H_2O_2 , persulphuric acid (Caro's acid) is formed. On account of their stableness the peroxides and per-salts form excellent substitutes for H_2O_2 ; they have also the advantage over solutions of H_2O_2 , that their oxygen is liberated more gradually.

The peroxides are decomposed by diluted acids forming H_2O_2 and the salt of the metallic radicle of the peroxide. The commercial products are mostly mixtures containing but a limited amount of real peroxide.

SODIUM PEROXIDE, Na_2O_2 .

Sodium peroxide was for the first time prepared by the French chemists Gay-Lussac and Thénard by heating metallic sodium (or sodium hydrate) in silver crucibles. The chemically pure product was first obtained by Harcourt by heating sodium in a current of oxygen. Sodium peroxide may be prepared on a large scale by heating metallic sodium to 300 deg. Cent. in aluminium vessels and leading dry air free from carbon dioxide over it. A similar process¹ consists in fusing sodium and intermingling air (or a gaseous oxidizing agent) in excess therewith. According to U. S. Patent, No. 879,452, sodium peroxide is obtained by oxidizing the metal with an oxidizing agent (air) at such a temperature that the resulting oxide (or peroxide) is instantly melted by the heat generated in the reaction. In small quantities the peroxide may be prepared by heating to redness a mixture of sodium nitrate until evolution of oxygen sets in, when small pellets of metallic sodium are added. E. de Haen proposes to obtain Na_2O_2 on a technical scale by heating sodium nitrate with lime or magnesia to redness. The porous mass thus obtained contains sodium oxide; by leading pure air over this product at a temperature of 500 deg. Cent. sodium peroxide is formed. H. Y. Castner prepares nearly-pure Na_2O_2 (oxone) by a continuous process. According to F. Bergius, sodium peroxide is also obtained by dissolving barium dioxide in fused sodium hydrate and heating in a current of air or oxygen until completely oxidized. The Na_2O_2 is then isolated by treating with an inert liquid, such as alcohol, which may be recovered by distillation. A hydrated sodium peroxide has been obtained² by mixing the peroxide with six to eight times its weight of crushed ice, whereupon the temperature drops considerably and small, white crystals of the formula $Na_2O_2 \cdot 8H_2O$ are formed. They are washed in alcohol and then allowed to dry. Schöne prepares a sodium peroxide hydrate by evaporating a mixture of H_2O_2 (3 to 4 per cent) and a 10 per cent solution of sodium hydrate, or by precipitating such a solution with $1\frac{1}{2}$ to 2 times its volume of absolute alcohol.

Sodium peroxide is a yellowish white powder, is hygroscopic and absorbs carbon dioxide from the air with liberation of oxygen. Exposed to air it therefore becomes damp and deteriorates. It must always be kept in tightly closed containers. When dissolved in ice-water it is decomposed into H_2O_2 and caustic soda with evolution of heat: $Na_2O_2 + 2 H_2O = 2 NaOH + H_2O_2$. In

water of ordinary temperature it dissolves with evolution of oxygen, heat also being generated: $Na_2O_2 + H_2O = 2 NaOH + O$. In water containing acids (if kept cool) it dissolves without evolution of oxygen, H_2O_2 and the corresponding sodium salt being formed. Commercial



Fig. 1.—Autogenor Fitted with Nebulizer and Cut-off.

sodium peroxide contains about 20 per cent of available oxygen. While Na_2O_2 has a yellow tint, the hydrated peroxide is of a pure white color, is not hygroscopic, although it is decomposed by carbon dioxide. It contains 5 per cent of active oxygen. Sodium peroxide is not explosive by itself, but on account of its oxidizing action on most organic substances it is capable, in the presence of water or moisture, to ignite cotton, wool, straw, etc. As the commercial peroxide often contains small quantities of non-oxidized sodium, it is also liable to cause explosion on being dissolved in water.

Various attempts have been made to prepare stable peroxides or mixtures containing such. A stable product may be obtained by partly removing the water of crystallization from Na_2O_2 . This is accomplished by heating to 45 deg. Cent. in a vacuum and at the same time gradually admitting small quantities of air.³ According to E. Thomann, a product which is unaffected by atmospheric moisture or by contact with organic substances



Fig. 2.—The Autogenor Taken Apart, Showing Outer Vessel and Inner Parts.

(e. g., soap powder) may be obtained by coating Na_2O_2 with an acid substance, such as potassium bisulphate, aluminium sulphate, boric acid, etc. Stolz and Kambli prepare a sodium peroxide mixture in permanent form by incorporating 10 parts of the peroxide with 12 parts of fused potassium nitrate. On cooling it gives a compact dense product, which, when immersed in water, sinks and generates hydrogen peroxide slowly and regu-

larly without danger of explosion. It may be cast in molds and then coated with resin or stearic acid which form a soap with the alkali liberated by the action of water. Sarason mixes the Na_2O_2 with ammonium salts and obtains a preparation which is claimed to be absolutely harmless and convenient to handle. By mixing the peroxide with sodium pyrophosphate, a product is formed which only very slowly liberates oxygen. The French chemist, G. F. Jaubert, has put on the market several preparations containing Na_2O_2 , which evolve oxygen in a manner analogous to the production of acetylene. By fusing under pressure mixtures of Na_2O_2 with suitable acid salts, such as anhydrous bisulphate, or with dry acids, such as oxalic or tartaric acid, a useful substance is obtained. Or the peroxide may be mixed with potassium permanganate or salts of copper, cobalt, nickel, etc., in the presence of water and the whole agglomerated by compression. A suitable mixture is made of 100 parts of Na_2O_2 and 2 to 5 parts of copper sulphate. Perhaps the best known of Jaubert's preparations is his "Oxolith." It is composed of 100 parts (by weight) of dry bleaching powder and 39 parts of sodium peroxide. It is a slightly yellow powder which when subjected to strong pressure forms a hard and dense mass. Oxolith is put on the market in compressed blocks or in form of small pellets and is said to be far less liable to become decomposed by water and heat than the ordinary peroxide. It is inexpensive and when placed in water it gradually gives off $CaOCl_2 + Na_2O_2 = CaO + 2 NaCl + O_2$. According to a process patented by D. E. Parker, sodium peroxide is subjected to an electric current which causes it to melt, the temperature being maintained at such a point (710 to 718 deg. Fahr.) as to liberate any carbon dioxide (which impairs the value of the peroxide as an oxygen-producing agent) contained therein without freeing the oxygen from the molten material. The product is then briquetted in suitable molds. This preparation of fused Na_2O_2 has been introduced under the name of oxone and is perhaps the best known and, in this country at least, the most extensively used sodium peroxide preparation. It forms a dense body of specific gravity 2.43, hard, but not brittle, and of a grayish color. Thrown into water it gives off 322 times its volume of pure oxygen (at 760 millimeters and 0 deg. Cent.).

Uses of Sodium Peroxide.—Many are the uses which have been found for Na_2O_2 since it has been commercially procurable. It is chiefly used for the production of pure oxygen as an oxidizing agent, as a disinfecting and bleaching agent and as a detergent. Generally speaking the uses of Na_2O_2 are identical with those of hydrogen peroxide; but sodium peroxide is said to be 13 times stronger than H_2O_2 solution (3 per cent strength). One pound of Na_2O_2 is equal to 1.3 gallons of commercial hydrogen peroxide. A saving is also effected in carriage; besides Na_2O_2 keeps indefinitely in well-closed containers. When first introduced it was thought by some that it would supersede barium dioxide in the manufacture of hydrogen peroxide, but it was found to be more expensive and dangerous to use. Sodium peroxide is, however, now frequently used for the preparation of chemically pure oxygen in the laboratory, for lecture purpose and especially in therapeutics, where the use of compressed oxygen in heavy cylinders is often cumbersome and inconvenient. The use of pure (powdered) Na_2O_2 for the production of oxygen gas is, however, not without danger; the reaction, when the peroxide is brought in contact with water, often becomes violent. It has, therefore, been found necessary to mix the peroxide with indifferent substances in order to cause a slower and more gradual evolution of gas. Turner recommends a mixture of equal parts of fused Na_2O_2 and crystallized sodium sulphate or carbonate. According to Dr. L. Wolter⁴ preparations which remain stable even in moist atmosphere and which evolve oxygen gradually when brought in contact with water acidified with hydrochloric acid may be obtained by fusing together sodium peroxide with a neutral salt which melts without being decomposed, and which does not react on the peroxide. The best results were obtained by fusing together 100 grammes of sodium peroxide, 25 grammes magnesia and 100 grammes potassium nitrate. This substance is especially adapted for the production of oxygen in the laboratory in Kipp's apparatus; its stability may be increased by immersing large pieces of this substance in molten paraffin. A gradual evolution of oxygen may also be obtained by introducing ordinary Na_2O_2 into a 1 to 5 per cent solution of cop-

¹ U. S. pat. 739,375.

² French pat. 370,321.

³ Germ. pat. 247,988 of 1910.

⁴ Chem. Zeitung, 1908, p. 1097.

per sulphate or chloride. By mixing sodium peroxide with sodium perchlorate a product is obtained which melts at 214 to 233 deg. Cent. without giving off oxygen, although the melting point of the individual chemicals is much higher. At 280 to 310 deg. Cent. the perchlorate parts with its oxygen; if the residue is brought in contact with water or steam the peroxide is decomposed and oxygen again given off. Or if water is added to the fused mixture, the oxygen of the peroxide is driven out and the heat evolved during the process is sufficient to decompose the perchlorate, which also parts with all its oxygen. Caram recommends the preparation of oxygen from peroxides (as well as from perborates) by the catalytic action of colloidal manganese dioxide, employed either dry or formed *in situ*. The colloid is made by oxidizing manganous salts or by reducing manganates or permanganates in the presence of a protective colloid such as gelatine, casein, gum; or by reducing permanganates in very diluted alkaline solutions. Bernam uses a mixture of 5 parts Na_2O_2 , 55 parts powdered talcum and 40 parts of tannic acid, the latter to neutralize the alkali.

Special generators have been constructed for producing oxygen gas from sodium peroxide. Jaubert has devised two forms of apparatus for use in connection with his "oxilith"; one for laboratory and medical use, the other for technical purposes.⁵ A small portable device for the extemporaneous production of oxygen for therapeutic or other purpose from the substance "oxone," is much in use in this country. This oxone generator consists of an outer jacket holding water and an inside cylinder to be immersed into the former. The inside cylinder has no bottom, so that oxone cartridges can be introduced into it. A needle valve on the upper portion of the cylinder serves to regulate the generation and pressure of the gas. The cover is also provided with an air vent and a nipple for attaching the washbottle. The cartridge consists of a hermetically sealed tin filled with the fused peroxide and will keep for years. For use, a few holes are punched in the top and bottom of the cartridge which is placed into the inside cylinder of the generator. It is then submerged in the outer vessel and locked in position by means of thumb-screws. Generation of oxygen sets in an opening the needle valve and ceases on closing same. One cartridge produces about 7 gallons of oxygen of 99.3 per cent purity, the impurity consisting simply of water vapor mechanically carried along by the energy of the reaction. An oxygen generator which yields the gas under any required pressure from 0 to 50 pounds per square inch has recently been put on the market by the manufacturers of the oxone generator just described under the name of *Autogenor*. It is a simple instrument in appearance, very much like a coffee-pot, 13 inches high and weighing but 7 pounds (Figs. 1 and 2). This apparatus may be used in connection with the oxy-hydrogen or oxy-acetylene blow-pipe or for calcium lights, but is especially suitable for medical use. It replaces tank oxygen, being more convenient than the latter for those who are remote from centers of distribution of compressed gas. The *Autogenor* is well adapted for atomization and vaporization of therapeutic agents, oils and disinfectants (Fig. 3). It substitutes oxygen for air which hitherto has almost exclusively been used as driving and distributing medium for vaporization and atomization. An *Autogenor* placed in the hospital ward or in a public assembly room, with 10 per cent alcohol or 2 per cent formaldehyde in the atomizer, or eucalyptus oil 1 part and white oil 9 parts in the vaporizer, with instruction to turn on the valve every hour for 5 minutes, will deodorize and disinfect the atmosphere, and at the same time add oxygen to it.⁶ Dr. L. B. Couch, who has made extensive experiments with oxy-formaldehyde spray disinfection, thinks that it would supersede all other methods of disinfection in use, especially for the prevention of epidemics in public schools and communities. In a paper read at the Fifteenth International Congress on Hygiene and Demography, recently held in Washington, D. C., Dr. F. Ainsley Walker stated that it was impossible to rid schools of all infected children and, therefore, he suggested that class rooms be sprayed with disinfectants each day to kill germs thrown off by unhealthy pupils. For this purpose the combination of freshly produced oxygen, formaldehyde and moisture would doubtless be most effective, more so than mere formaldehyde fumigation. By the aid of the oxygen-pressure generator and attached vaporizer, a continuous spray 1 to 3 feet in diameter and 6 to 10 feet long is obtained according as the pressure ranges from 10 to 50 pounds per square inch (Fig. 4). As stated by Dr. Couch,⁷ a schoolroom 30 by 40 by 14 may by such a spray be thoroughly disinfected within 8 minutes; while the whole body, skin, clothing, hair, as well as the whole respiratory mucous membranes can be disinfected in 5 minutes. Seated in an ordinary chair, the person exposed

to contagion is covered with a closed rubber cloak, only the head being exposed to air. Beneath the cloak and resting on the floor, the *Autogenor* sends out its spray of water and oxy-formaldehyde, the gases completely saturating the whole body and clothing of the suspect, who remains from 5 to 10 minutes in the disinfecting robe. He is then made to inhale—from another *Autogenor*—four long breaths of air and water vapor, charged with formaldehyde in proportions of 1.250 to 1.500, exhaling the vapor through the nose. In this way the whole respiratory mucous membrane is thoroughly disinfected and all existing pathogenic germs are completely destroyed.

Sodium peroxide is the most convenient source of oxygen, and since the latter is obtained pure and in the

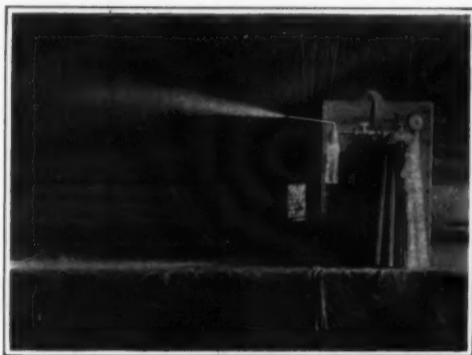


Fig. 3.—Autogenor in Action, Showing an Oxy-formaldehyde Spray 10 feet Long and 3 feet in Diameter.

nascent state, it possesses many advantages over compressed oxygen, although the high cost of the gas obtained in this way (10 to 15 cents per cubic foot) precludes its use for technical purposes. A case where sodium peroxide was resorted to to save a man's life who had been rendered unconscious by gas, was reported at the Ninth General Meeting of the American Electro Chemical Society in 1906. No oxygen in tank was available at the works where the accident happened, but a can of sodium peroxide was at hand. It was placed in an ordinary hydrogen generator and the gas forced into the man's lungs through a rubber tube placed in his mouth by the aid of artificial respiration. Although the man had already stopped breathing and his heart had ceased beating, he regained consciousness inside of 15 minutes after the administration of oxygen. Oxone and similar Na_2O_2 preparations are adaptable for shipment to any distance and offer no danger of explosion or combustion, their only inconvenience being their strong causticity, which has to be taken into consideration when handling them. On account of its caustic properties sodium peroxide is unsuitable for medical or toilet preparations, although it is sometimes used incorporated with soaps. The causticity may be lessened by combining with fats and resins, also with carbon tetrachloride. Unna recommends soaps and ointments containing Na_2O_2 (e. g., 3 parts liquid paraffin, 7 parts of dry medical soap and 2 to 20 per cent of Na_2O_2) in the treatment of eczema, lichen cornuus, acne, etc. Mixed with alkali bicarbonates and chlorides it has been used as a preparation for oxygen-baths. Blatz recommends sodium peroxide for the sterilization of water. He proposes to add to the water citric acid and then the peroxide, and states that with proportions of 1/1,000, water containing many bacteria is sterilized

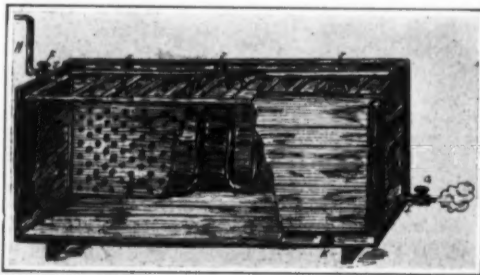


Fig. 4.—Vat for Sodium Peroxide Bleaching.

in 24 hours, cholera bacilli are killed in 3 hours and typhoid bacilli in 6 hours.

Oxone, oxilith and like preparations are excellent agents for the production of artificial air to maintain respiration for an indefinite period in an inclosed space. Aside of being capable of producing oxygen, they absorb carbon dioxide and destroy the toxins of exhalation, all by the effect of moisture from the breath, and therefore form an ideal substance for the regeneration and purification of air in respirators, rescue apparatus (oxygen helmets), submarines, etc. George T. Brindley and

Richard V. Foregger, in a paper read at the Ninth General Meeting of the American Electrochemical Society, 1906, told of experiments they had made with fused sodium peroxide on the regeneration of air for submarines, and state that they could guarantee to keep nine men alive in a submerged submarine for a period of 48 hours, or more.

Very likely sodium peroxide will in future play an important rôle in aeronautics, and replace the heavy oxygen tanks, which at present are being used to enable the aviator to endure the rarefied atmosphere of high altitudes. The French aviator, George Legagneux, who on September 17th established a new world's record for altitude, attaining a height of 18,766 feet, carried a supply of oxygen which he was obliged to use on reaching an altitude of 15,748 feet.

Sodium peroxide is further being used in the chemical laboratory for analysis and separation of manganese, iron, chromium, zinc, nickel and cobalt for reducing mercury, silver and gold and for the quantitative and qualitative analysis of arsenic, antimony and tin; in the analysis of ores, for the determination of the sulphur content of coke, coal and asphalt, as well as for the analysis of many organic substances. Sodium peroxide is also employed for extracting gold by the cyanide process and in various metallurgical operations (copper converter process, blast furnace, etc.). The use of the peroxide has further been recommended for supplying combustion engines (gasoline motors) of submarine boats and torpedoes,⁸ when operated under water, doing away with accumulators and electric motors.

By mixing sodium peroxide with coal dust, potato flour and water, a substance is obtained which has been recommended as an incandescent material.⁹ Sodium peroxide is also a good purifier for impure acetylene, having the advantage over other purifying agents of not liberating any chlorine. Villon recommends the peroxide for the purification of alcohol; 100 to 500 grammes of Na_2O_2 are added to 100 liters of alcohol allowed to stand aside for 24 hours and then rectifying the mixture.

In the textile industry, sodium peroxide is extensively used for bleaching all kinds of goods, especially such as are formed of animal fibers and tissues, e. g., wool, silk, hair, feathers, etc., but also for cotton bleaching. Bleaching of wool and mixtures with the aid of sodium peroxide has given exceptionally satisfactory results and has been found preferable to hydrogen peroxide. Sodium peroxide does not injure fiber of any kind and gives a permanent and pure white. In most bleaching processes the peroxide is dissolved in acidified water in order to neutralize the caustic soda which otherwise would corrode the fiber. The acid used must be free from iron. Magnesium sulphate (free from chlorine) may be used instead of the acid. Wool and half-wool must be completely freed from fat before being introduced into the bleaching liquor, ammonia being usually employed for that purpose. Fig. 4 shows a bleaching kler employed in sodium peroxide bleaching. The vat, which is made entirely of wood, is provided with a leaden steampipe *C* along the one side (or arranged at the bottom beneath a false bottom); the supply pipe is fitted with a valve *F*. The waste pipe *I* is provided with a safety valve, not shown in the sketch. A wooden partition *B*, having numerous holes, separates the heating coil from the goods in the vat, which are held down by means of wooden strips *D*, held in place by wooden blocks *J*. No metal except lead must come in contact with the bleaching liquor. Wolfenstein, in a recent patent, recommends the use of tin vessels to which a coat of stannic oxide is applied. For details of the various bleaching processes in use, the reader must be referred to the literature in existence. In bleaching straw the sulphuric acid mostly used to acidify the bath is replaced by oxalic acid. In addition to textiles, sodium peroxide is also suitable for bleaching felt, wood, horn, bamboo, bone, ivory, sponges, bristles, wax, oils and fats. According to E. Scheitlin a stable washing and bleaching agent is obtained by mixing 1 part of Na_2O_2 with 2 to 3 parts of rosin. By adding small quantities of hydrocarbons or acetie ether, the rosin is gelatinized and a plastic mass is formed which decomposes only above 80 deg. Cent. P. Roser recommends mixtures of 55 parts of powdered sodium peroxide and 45 parts of carbon tetrachloride, or 62 parts of the peroxide with 100 parts of carbon tetrachloride and 168 parts of sodium bicarbonate (or boric acid). A soap containing active oxygen is obtained, according to Wolfenstein, by causing the peroxide to act upon free fatty acids in presence of heat. Beltzer uses a soap made from castor oil, rosin, sodium carbonate and sodium silicate, mixing the dry soap powder with sodium carbonate and sodium peroxide and subjecting the whole to hydraulic pressure. Gruner's washing powder contains 80 per cent of pure soap and 9 per cent of Na_2O_2 . Like hydrogen peroxide, sodium peroxide may also be used as a spot remover; nearly all stains on linen can be completely removed by its use in washing.

⁵ Germ. pat. 213,686 of 1906.

⁶ Germ. pat. 218,030 of 1907.

⁷ SCIENTIFIC AMERICAN, September 27th, 1902, p. 205.

⁸ R. V. Foregger, Peroxygen Bull., No. 5.

⁹ Information received from Dr. L. B. Couch in a personal communication to the writer.

City Passenger Transportation in the United States*

Report of An English Engineer

By George Duncan Snyder, M.Inst.C.E.

This paper treats of city passenger transportation lines other than tramways and the city portion of through railways.

The cities in the United States having such lines, and their metropolitan populations in 1910, were:

New York	6,474,568
Chicago	2,446,921
Philadelphia	1,972,392
Boston	1,520,420

HISTORY.

New York.—The first tramway was worked in 1832 and the first omnibus-line in 1835. The first elevated railway was worked in 1871, and was followed by lines in Brooklyn and Jersey City. The first underground railway was opened 27th October, 1904.

The city is constructing new lines and has about concluded agreements for the operation of a dual transportation system by the Interborough Rapid Transit Company, who operate the present subway, and the Brooklyn Rapid Transit Company.

The Hudson River tunnels were first worked 26th February, 1908. A tramway tunnel has been built across the East River at Forty-second Street, but has not yet been worked.

New York has 133.17 miles of transit lines, and 95 miles under construction.

Chicago.—The first elevated railway, the Southside line, was opened on 6th June, 1892, using steam locomotives. This was followed by lines to the west and northwest, which were later connected together by the Union loop in the center of the city. The motive power was changed to electricity between 1896 and 1898. The length of these lines aggregates 74.56 miles. The municipality now proposes to construct a system of underground railways, 56 miles long, at an estimated cost of \$96,257,000, the equipment of which will cost \$34,844,000 more.

Boston.—The Tremont Street subway for tram lines was opened 1st September, 1897, and was followed by the elevated railway on Atlantic Avenue in 1901. A tunnel crossing the harbor to East Boston, for tram lines, was opened in 1904. The Washington Street subway for trains of the elevated system was opened 30th November, 1908. The elevated railway was extended to Forest Hills in 1900. The Cambridge subway was completed in 1912, and the East Cambridge elevated tram line in the same year.

Surface, elevated and underground lines are under one management, and passengers are permitted to transfer from one to the other without payment of extra fare. The existing lines are 24.48 miles long, and 6.88 miles are under construction.

Philadelphia.—Philadelphia has a combined underground and elevated system 7.41 miles long, and a line on private right of way, 17 miles long.

CONSTRUCTION AND WORKING.

There are 250 miles of high-speed city transit-lines in the United States, and 174 miles proposed or under construction.

Such lines are either built for multiple-unit trains, for tram lines, or to cross obstacles to continuous transit, such as rivers, mountains, etc. Physically they are built under streets, over streets, or elevated or depressed on purchased land.

Elevated lines are preferred from the standpoint of passengers, while underground lines are less of an obstruction to streets and less damaging to the adjoining property.

New York and Chicago have three- and four-track lines for operation of low- and high-speed trains, while Philadelphia has a four-track line with trains and tramways, and Boston's four-track line is used entirely by tramways.

Stations.—A single platform between tracks is the cheaper to operate. Four-track lines have express station-platforms between local and express tracks and side platforms at local stations. At the terminus at Brooklyn Bridge 35,000 passengers per hour are dealt with.

Shallow versus Deep Level.—Practically all underground railways are of the shallow type. The four-track line on Lexington Avenue (New York) is being constructed with local tracks near the surface and express tracks tunneled at a deep level. Deep-level lines cause less inconvenience during construction, but are

more expensive to work on account of the necessity for lifts.

Typical Sections.—The internal height varies from 13 feet 2 inches to 15 feet 4 inches, and the width for a single track from 11 feet 6 inches to 13 feet 2 inches. The construction for shallow subways is either of steel beams in roof and sides, embedded in concrete, or of reinforced concrete.

Methods of Construction.—Construction is carried on under a temporary wooden flooring for the street. A portion of the Brooklyn subway was excavated with a steam shovel. The depth of the subways necessitates the underpinning of adjoining building foundations and the temporary support of the elevated railway. Subway lining is of concrete, excepting the iron-lined subaqueous tunnels. Rock tunnels are driven with a top heading. Roof shields have been successfully used in soft ground in Boston. Subaqueous tunnels are usually driven with shields and compressed air, and lined with cast iron. The East Boston tunnel was driven with a roof shield and lined with concrete.

Ventilation.—In shallow subways ventilation is effected by exhaust fans between stations. The Hudson and Manhattan Railroad use exhaust fans assisted by the piston action of the trains.

Elevated Railways.—On narrow streets the elevated columns are placed in the footwalk and on wide streets in the carriage-way. The increase in loads since the first lines were built has necessitated their strengthening or rebuilding. Present practice is to use riveted plate girders. Since 1893 steel has been used instead of iron. Double-track structures weigh 900 pounds to 1,000 pounds per linear foot. Solid concrete floors, with ballasted tracks, have been used on recent structures. Lines on private right of way are built in suburbs, and are elevated or depressed to avoid level crossings with streets.

Bridges.—The great bridges over the East River now form part of through transit routes, which avoids the terminus problem which existed when they were worked independently.

Length of Trains.—The length of trains has increased from three cars on the first elevated to ten cars in the New York subway, and still longer trains have been suggested.

Density of Traffic.—The density of traffic on the New York subway is 4,000,000 passengers per mile of track per annum. The peak load on most lines is between 5 and 6 P. M., and amounts to about 15 per cent of the total for the day. Monday generally has the maximum traffic for the week, amounting to about 17 per cent, and Sunday the minimum—about 9 per cent. About 7 per cent of the annual traffic is carried in July and 9 per cent in December.

The Riding Habit.—The number of passengers per annum is increasing as the square of the population. New York had 43 passengers per head of population in 1860 and 322 in 1910, and if the present rate of increase is maintained in the future, this will amount to 913 in 1950.

Fares.—The fare is almost universally 5 cents, regardless of the distance, although much dissatisfaction with this arbitrary rate exists among managers.

Cars.—New cars are being made of steel, and the tendency is to increase the size, the most recent being 70 feet long, 9 feet 6 inches wide, and 12 feet 6 inches high, weighing from 86,000 pounds to 120,000 pounds.

Permanent Way, etc.—Underground lines use "T" rails on wooden sleepers, laid in crushed stone. In Philadelphia the rail is attached to short wooden blocks, fastened to a steel box girder embedded in concrete.

The maximum gradients are from 1 in 33 to 1 in 12.5, and the minimum radii of curves from 90 feet to 150 feet.

Signals and Interlocking.—Automatic block signals are not used on the older elevated lines nor on the local tracks of the New York subway except at special points. They are used on express tracks in New York and Chicago, and for multiple-unit trains in Boston and Philadelphia.

A headway of 90 seconds can be maintained with automatic block signals with a speed of 40 miles per hour. A headway of 20 seconds has been maintained without signals and with low speed.

Methods of Working.—Four-track lines are worked with express trains on one pair of tracks, and local trains, or tram lines, on the other. On three-track lines express trains are run in one direction in the morn-

ing and in the other direction during the evening hours.

Franchise Conditions.—The earlier lines were built with private capital under perpetual franchises, but the municipalities are now building the lines and leasing the right to work them for a term of years.

Cost.—Underground lines cost \$835,000 to \$1,000,000 per mile of track, and elevated lines \$200,000 to \$600,000 per mile of track—without equipment.

In New York city earth excavation cost \$2.90 to \$6.25 per cubic yard, and rock excavation \$4 to \$12; tunneling, \$8.25 to \$9.50 per cubic yard; concrete, \$8 to \$11 per cubic yard.

Cost of Working.—The cost of working varies from 44 per cent to 70 per cent of the gross receipts. The cost per car-mile is 9½ cents to 20 cents.

Conclusion.—Exclusive transit lines have only been built in cities of about 1,000,000 inhabitants, but may prove profitable in smaller cities where the riding habit of the population is pronounced.

The Frequency of Tubercular Infection

EVERYONE knows that tuberculosis, especially of the lungs, is an exceedingly common disease and is responsible for a large proportion of the deaths which occur in the population. It is perhaps not quite so generally realized just how common tubercular infections, including those which do not cause deaths, are in the general population. We read in a recent number of *Science Progress* that "Ribbert has published the records of 5,000 consecutive post-mortem examinations of patients that died of various diseases in general hospitals. Traces of tuberculosis were found in every one of these cases. In all similar records known to the writer the lowest percentage of cases in which traces of tuberculosis have been detected is 25. It has also been shown that very frequently the signs that are met with of tubercular disease of long standing indicate very extensive damage and destruction of tissue, not merely slight infection. Yet such individuals have recovered from the disease and this has had no permanent effect upon their health." Such cases as these are of double interest. They show on the one hand the extreme prevalence of the disease; on the other hand they have this comforting feature that we learn from them that the disease is far from being incurable. In fact, in a very large number of cases, the cure has been effected without the patient ever knowing that he had suffered from it. This must not, of course, be construed to mean that the disease is to be lightly considered or the patient allowed to rely upon his own vitality for recovery. It is well known that when the disease has proceeded to a certain stage, chances of recovery are very much reduced, and it is very essential of course that medical attention be received before this stage is reached.

Theory vs. Practice

How often do we see theory and practice referred to in this manner. The right way would be to say "Theory and Practice"—not "Theory versus Practice." If theory and practice appear to disagree, either the theory or the practice is wrong, for when rightly applied, theory goes hand in hand with practice everywhere. There is no shop operation so simple that it does not in some way involve the application of a theoretical principle. There is no designer or mechanical engineer, no matter how highly educated, who can successfully design the simplest device without taking into account some practical requirement. The man who looks upon theory as an abstract matter, useless in his practical work, merely proclaims his ignorance. The man who prizes theory so highly that he believes he can afford to disregard the practical requirements and leave them to the shop man to decide, thinking that it is below his own dignity to bother with such details, paves the way for inefficiency and confusion. One of the reasons that America has excelled in the art of machine building is that our practical shop men have had more "theory" than the average European workmen, and that our engineers and designers have had more practical training than the technical leaders on the other side. Let it be reiterated that practice without theory is almost as useless as theory without practice, and that there is no such thing as "theory versus practice;" it is "theory and practice" that achieves results.—*Machinery.*

* Abstract of a paper read before the (British) Institution of Civil Engineers.



Fig. 1.



Fig. 2.

Figs. 1, 2, and 3.—Curves of Undamped Rolling of Ship in Different Seas.



Fig. 3.

Gyroscopic Stabilizer for Ships*

By Elmer A. Sperry

THE navies of the world, in the struggle for supremacy, are making for maritime progress as no other force could. These developments, considered strictly from the present-day standpoint of conservation, more than justify the entire expenditure, and though remaining for a time in the possession of one nation, soon become world property. Our own navy has been in the forefront of this progress. Consider the recent great advancement of knowledge on the relation between form-lines, speed and power of ships; very largely the product of our own model tank at Washington, due to the broad policies and wonderful foresight of our navy and the rare ability and devotion of its personnel. The marked reduction in fuel, in many instances halving the fuel requirements in marine transportation, is certainly a proud monument to any navy and one our own nation should be proud of. And this is only one of its achievements, all accomplished so quietly that the nation does not realize nor appreciate it as do the more maritime nations over the seas. These may all be considered as "by-products," simply incidental to the real development or the real object and significance of the navy in its relation to our place among the nations.

The engineers of our navy have been responsible for numerous advances in power and fuel economy, not only by establishing efficient and scientific methods of managing boiler and engine plants, but also by numerous improvements in the design of engine itself.

The subject with which this paper deals is one that has received attention and has for some time been under investigation by the architects of our navy. Two years ago I was permitted to touch upon some small portion of this work; since that time the progress has been marked. In fact, with the data now available, it is possible to design a stabilizing plant which will confine the roll of a ship to almost any limit desired, regardless of the displacement and period of that ship. The same type of plant may be used for rolling the ship at will, which feature has an important application in our icebound waters.

It is felt that when the data relating to the active type of gyros is ready to be given to the world, the important subject of stabilizing ships will receive by far its most interesting chapter and not unlikely its most important contribution.

The advantages to be derived by efficiently stabilizing ships may be summarized as follows:

1.—ADVANTAGES COMMON TO ALL SEAGOING SHIPS.

(a) Saving in power and consequent saving in fuel owing to the ability to maintain the shortest course between two points in bad weather, inasmuch as the ship will be in no danger from excessive rolling when steaming even in the trough of the sea.

(b) Saving in power and consequent saving in fuel owing to the fact that the wetted surface is not increased by wallowing, inasmuch as the vessel is always held on an even keel.

(c) Saving in power and consequent saving in fuel by elimination of rolling against the relatively stiff water when under way. This increase in the power required to drive a vessel which is rolling is due to what is known as the keel or form line impingement. It is illustrated by the longer period of the roll of the vessel when steaming as compared to the period when not under way.

(d) Saving in power and consequent saving in fuel by reducing the yawing and tendency to follow a sinuous course.

(e) Saving in fuel and weight by the elimination of bilge keels.

(f) Making small ships as comfortable for passengers as large ships, while at the same time being able to prevent the largest from rolling.

(g) Eliminating stresses in the structure of the ship and the stresses in the accessories and auxiliaries contained within the ship, caused by excessive rolling.

(h) Preventing deterioration in cargo caused by ex-

cessive rolling. This would particularly apply to ships carrying live stock as cargo.

(i) Ability to roll the ship artificially for the purpose of freeing from or rolling off sand or mud banks by opening the contacting crevices and gradually liquifying the encumbent mass.

(j) Making a ship more seaworthy by preventing the shipping of seas due to rolling.

2.—ADVANTAGES APPLYING ESPECIALLY TO MEN-OF-WAR.

(a) Decreasing the amount of under-water armor, which it is necessary to place on men-of-war at present in order to protect that portion of the hull which might be exposed to the enemy by rolling.

(b) Steady gun platform.

(c) Ability to go into action in any state of sea or upon any course in rough weather.

(d) Improving the condition of men and officers by eliminating the fatiguing and other effects of incessant and constant rolling.

(e) Ability to roll the ship artificially to standard angles, if so desired, in competitive target practice.

Since the unique and enlightening discussion recorded in the last proceedings of the British Institution of Naval Architects, the character and extent of the early work of Sir Philip Watts, Prof. Biles and others in attempts at improving the stability of ships by the use of damping tanks, in England, have been better understood. The original detailed proposition of Sir Philip for the construction of the tanks on the "Invincible" and other ships has also become known, and the completeness of their understanding of the underlying principle of the operation of these tanks, namely, their necessary synchronism with the ship's period, for developing secondary resonance, leaves little to be desired.

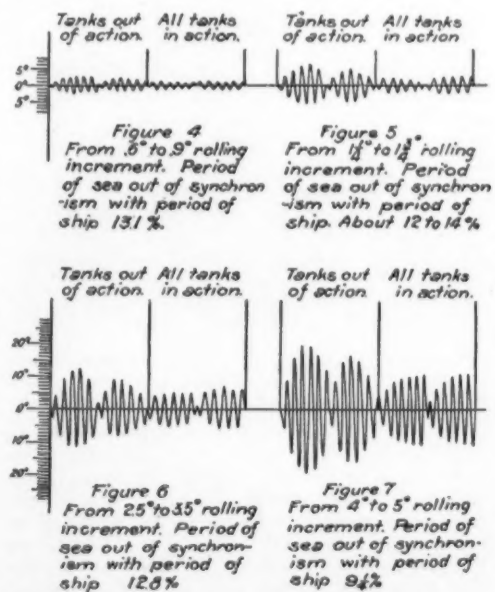
There is no doubt about the very great desirability of steady ships. We believe that shipping interests and the marine generally are indebted to the recent German workers for again bringing this important subject into prominence. Both Dr. Schliek and Mr. Frahm have been working in the same line in one particular, namely, damping roll of ships after motion of some magnitude has set in. In point of fact, they diminish the amount of such roll by setting up counter forces having their origin in the motions themselves and depending upon such motions for their existence.

Turning again to the operation of damping tanks in the original paper by Mr. Frahm, much stress is laid

upon the point that the fundamental principle of this operation, using his own words, "consists in setting up a secondary and artificial resonance in order to annihilate the primary resonance between waves and ship, it being on this fact that their operation is based."

The very grave question arises: Is the basic proposition here enunciated true? Is there any primary resonance between waves and ship or really any approach to such a condition? This question was raised in this discussion by one of the nestors of this art, and a fact was pointed out by him which has been the basis of minute analysis on this side of the Atlantic for some years past, namely, the oft-recurring cycles, or groups, universally present in rolling records. The facts thus brought out by Sir John I. Thornycroft agree in the main with the results reached early in this investigation by similar analysis on this side. These cycles are to be seen in any rolling record, for instance, in Figs. 1, 2, and 3, where it will be seen that the rolling gradually increases to a maximum and then decreases to a minimum, whereupon another increase takes place, to be followed by another decrease and so on. The sea is doing work upon the ship for a time and then, in the words of Thornycroft, "it again undoes its work." In a very choppy sea the recurrence of these cycles is very much accentuated; the groups become smaller and less regular and sometimes more difficult to trace, but still they are there. This can point to but one conclusion, namely, the absence of anything that approaches true resonance between waves and ship. It also argues strongly against any stabilizing device which is limited to resonance phenomena only, be it primary or secondary resonance. Let us examine these curves more minutely. It will be observed that at the end of each cycle, before the next one starts, there is usually a change, more or less definite, in the phase of the period where there is an apparent "fault" in the regularity of the curves. The curves in Fig. 1 are taken from a very favorable sea, and when we examine curves 1, 2, and 3, which are taken from a less favorable sea, we see that these faults are more numerous and occur with greater frequency. With this feature, which is characteristic of all rolling of ships, how can it be successfully attacked by a device the underlying principle of which depends upon periodicity and synchronism? The water in the damping tanks can only create its damping movements as a result of regular oscillations, and if this oscillation is irregular the reactions fail to be propagated, and when the period changes what force is there present to readjust the operation to the new condition? Of course the answer to all of these questions is that tanks do not dampen under these conditions. It is true that there are easy rolling conditions in an old sea where they show to the greatest advantage and the damping action amounts to quite a comfortable percentage of the undamped rolling. But what are we to say of other sea conditions which are much more aggravated; and which, owing to their being more usual, are more important. It has been shown in this art that if the tanks are placed high and are supplied with water representing a sufficiently great percentage of the displacement of the ship the damping is good when the sea is synchronous, or approaches synchronism. But who is to guarantee the continuance of the synchronous condition? Certainly it does not exist on the high seas as we have found them.

Let us examine more minutely as to what happens when the sea is not synchronous. Let us consider the instances only slightly removed from synchronism. We find that the tanks have already practically failed to perform any useful function whatever and this approach or the percentage of the departure where they fail grows smaller and smaller as the seas grow heavier. Many curves have been analyzed with the tanks placed high, if not higher, and with the damping effect placed practically upon the conditions of the "Ypiranga" and "Corcovado," where these tanks are placed at the highest point relative



Figs. 4, 5, 6, and 7.—Curves Showing Action of Damping Tanks.

* Paper read before the Society of Naval Architects.

to the center of oscillation so far recorded. Upon an examination of these curves shown in Figs. 4 to 7, we discover that a departure of about 13 per cent in a comparatively calm sea, and of only about 9 per cent in a heavy sea, is sufficient to practically nullify the usefulness of the tanks.

A careful planimeter analysis of these curves which take into consideration the sum of all rolling motions of the boat over a given time, show that where the natural roll is given as 100 in each case, and under identical conditions, the rolling with all tanks in service amounts in Fig. 4 to 80; in Fig. 5 to 730, and in Fig. 6 to 68; whereas Fig. 7 shows that under full operation of the two damping tanks the area is 73.2. And in this latter case the departure of the wave impulse from true synchronism has only been $9\frac{1}{4}$ per cent. We can by no means consider any such performance as this as stabilizing the ship, nor in any sense of the word fulfilling the object before us; nor can it be considered as justifying the large burden in weight and the great amount of valuable space occupied amidships, in the position where space is most available and valuable for other purposes.

Again referring to the recorded action of these tanks, I do not think any of us would consider the performance shown in Figs. 4 to 7 as coming under the head of extinguished rolling or justifying the large expenditure of funds or of the boat's carrying capacity as stated.

It is sufficient to say that experience had demonstrated that damping tanks are disadvantageous, if not positively dangerous, when out of synchronism or when their period is not adjusted to that of the ship and, when so adjusted, then at each time the phase changes. In this connection it will be of interest to note that the period of the ship varies with its speed. A change of 30 per cent has been noted between period of a ship at 15 knots and that at 0 knots speed, thus showing that the period undergoes changes from more than one disturbing factor.

It is to an entirely different method of operation that I wish to call your attention, where the object has been to deal with individual increments or energizations of the ship regardless of synchronism or any other relation they may bear to the rolling period of the ship. By thus completely neutralizing each energization at its beginning or inception the ship is prevented from taking on or setting up motion.

As was pointed out by me in a paper read before the Society two years ago, each individual energization of the ship, regardless of its direction, amount, or its relation to period, should be dealt with as it arises; in this manner dealing with counteracting forces which are acting on the ship, as contradistinguished from damping the motion of the ship. The question of distinguishing between damping motion and resisting it was a year later quite distinctly stated by Sir John I. Thornycroft before the Royal Institution of Naval Architects and Marine Engineers at their London meeting. Sir John says that the perfect apparatus must not depend upon synchronism but must be entirely free from any synchronism between sea and ship, or between the period of the ship and that of the stabilizing apparatus. "The perfect stabilizer must act against the forces which are acting on the ship in such a way as to always resist the effect of the sea in producing motion." It has been found under service conditions that this is easily accomplished and is of full effect long before the ship has had time to get her great mass into the motion which constitutes rolling.

Some of the early attempts to use the gyroscope were unfortunate in that the gyro was passive, therefore free and uncontrolled as to its precessional movements. Experience has now been had in actual sea trials which confirm statements often put forward by the author heretofore, urging the great importance of having these precessional movements of the gyro at all times under perfect control. This arrangement introduces into the art a number of very important advantages which are now of definite and proven worth. This control on the one hand sets a constant limit to the otherwise almost limitless power of the gyro couple, while on the other hand it allows us to apply a measured stress of any desired magnitude, duration or direction and timed with precession. In this manner, the very great longitudinal metacentric height is available for athwartship purposes and may be in any desired amount added to the athwartship component. In fact the point has now been reached in this development, as demonstrated by sea trials, that the amount of the great longitudinal stability utilized athwartship may be always quantitative and proportional to the needs. With the adjunct the ship itself may be very tender and of low metacentric height because, as above stated, any desired amount of the very great longitudinal metacentric height may be added at will athwartship, and this without any regard to the rolling period of the ship. In this manner a comparatively small apparatus can be utilized in effectually holding the ship against motion, simply because each increment on the instant, and simul-

taneously with its development, is completely subjugated and neutralized before it has time to move the ship.

The gyro constitutes an ideal apparatus for this work inasmuch as it is perfectly safe. It is unnecessary to run the wheel at any but comparatively low stresses. In fact, the stresses present can be brought below those used in hull practice. The comparatively slow motion of the wheel is very inexpensive to develop and maintain, representing only a small fraction of the power required to propel bilge keels; and this power,

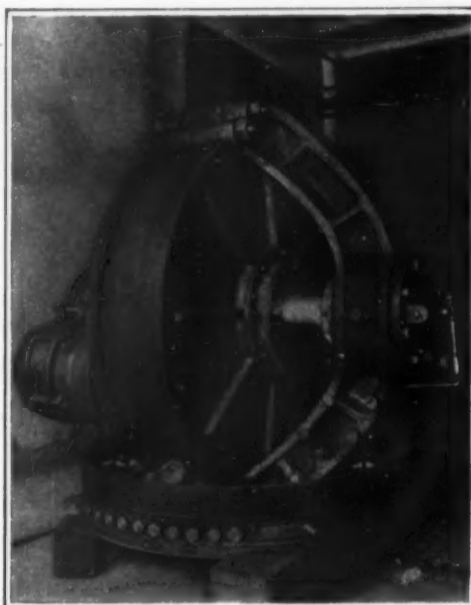


Fig. 8.—One of the Active Gyros of the "Worden."



Fig. 9.—One of the Active Gyros in the Tower During Shore Trials.

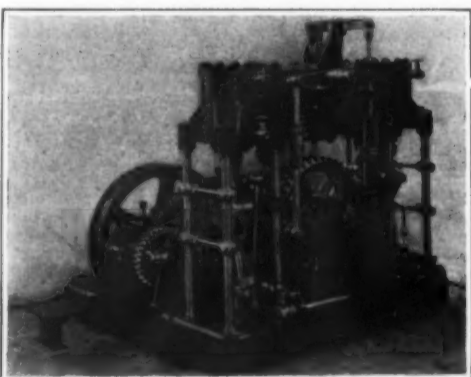


Fig. 10.—Photograph of the Precession Engine Before Installing.

small as it is, is only required when the necessity for stabilizing arises and then only in proportion to the seas running at the time, whereas the power for the bilge keels is omni-present; that is, it is a constant drag in all weathers. The power for operating the precession is trifling, only sufficient to absolutely control and limit the precession movements at all times. This arises from the fact that the constant tendency of the ship is to do precession-wise work upon the gyro.

The power required for the precession engine is almost nil, it being only sufficient to control the emplacement of the positive and negative energizations delivered to the ship.

Calculations dealing with a known tank equipment will illustrate the powers of the active gyro stabilizer. Let us take the case of Figs. 4 to 7, where a comparatively small fraction only of the roll was dampened, owing to the sea being out of synchronism even by but a slight percentage. The active equipment, as we have seen, is different. It most promptly deals with each momentary energization and "has no memory;" it cares not when nor from what direction the previous stress attacked the ship.

The surprisingly small magnitude of the whole gyro equipment is due largely to its unique method of operation; that is, it makes up in activity and promptness what it may seem to lack in size and weight.

Mr. Frahm mentions the tanks of the "Ypiranga" as changing the center of gravity of this vessel to the extent of some 2,700 foot-tons and states that gyros with this torque value had not been developed at that date. Gyroscopes can now be developed with low specific stresses of much greater torque value than this figure indicates, with the further gain that the center of gravity of the ship is not disturbed, nor would it undergo any change whatever. Moreover, with active gyros, torque of this magnitude is not required in ships of this tonnage and slow period for their effective stabilization. In connection with this statement regarding tanks, Mr. Frahm failed to point out how many oscillations of the ship were required before reactions of this magnitude had been set up, or if developed by one or two large oscillations how great an amplitude was required in such oscillation or oscillations of the ship. We now know what these are, and no ship could be considered stabilized while obsessed with this motion. One great difficulty with the tank proposition is that its phenomena are pendulous and resonant from start to finish, and must be in fact co-pendulous with the ship and therefore far too slow to deal with individual wave impulses. As a matter of fact, the first impulse or impulses are never dealt with, but instead the boat rolls in response to the increments in the act of creating the reaction within the tanks. Thus we see that as a matter of fact individual increments are never dealt with until an accumulation of a number of such impulses has resulted in actually rolling the ship, whereas the active gyro deals with each individual increment and no accumulation is possible.

Under the conditions shown by Figs. 4 to 7, we would have a steady ship in place of the oscillations recorded when all the tanks were in full operation and the plant itself is found to occupy between one tenth and one twentieth the space, the proportion being 1.5 to 21.7; the gyro plant weighing only 10 to 20 per cent of the tanks and contents. Again, this small space is practically independent of location. It need not occupy the most valuable amidship space nor extend entirely across the ship at point of greatest beam. It may even be divided up in two smaller spaces and stowed away at any point selected by the designer. In this way the small space required may be that which is least valuable in the whole ship. Again, the gyroscopic plant, unlike the tanks, is entirely independent of the height component of location, as it is found to operate equally well in the lowest part of the ship and is entirely independent of symmetry as to disposition in relation to the ship's center of oscillation. The gyro precessions being under individual control, each is rendered effective with full force. The action is thus incessant with no intermissions, whereas the sea is not consistent, sometimes delivering and sometimes absorbing energy from the ship, as seen in the rolling diagrams. This persistent and incessant action, always in the right direction, not waiting for the period but working more rapidly than the period, constitutes another explanation of the smallness of the necessary plant. In modern ships of low M. G. it is found that the active gyro equipment will represent only a fraction of one per cent of the displacement.

The gyros are built with vacuum casings, as shown in Fig. 8.

Ordinary babbitted bearings with a new system of oil distribution were employed.

The gyro equipment of the "Worden" contains the most powerful plant thus far constructed and the first with the spinning axis lying in their natural position, namely, horizontal.

The spindle is of high tensile strength steel of special quality, hardened and ground, resting at its ends in journals contained in centers of two half-ring castings, standing vertically in the figure; these are bolted together at top and bottom where they receive the vertical gudgeons and support the circular vacuum case in cast iron. The gudgeons on the vertical axis, one directly above and one directly below the gyro, are spherically seated bearings supplied with grease cups. The lower of these bearings is provided with a thrust

for supporting the weight. Vacuum glands surround the shaft on each side as shown in Fig. 8. The wheels are spun by small induction motors with friction drive of about two inches in width. These drives are found to work with about one per cent slip only. At the base of the gyro is a four-foot combined cable and braking drum with the braking surface above.

The gyros were placed in A-shaped towers, as shown in Fig. 9, at either side upon the deck, amidships, and between them there is a small, twin-cylinder steering engine driving a cable drum. This is shown in our illustration Fig. 10.

This engine is provided with the usual control and reversing pilot valve. The crank pin disks are provided with brakes, the arrangement being such that the brakes are set when the pilot valve is in its central position, the brakes being immediately released when steam is again admitted to the cylinder in either direction. This engine was also provided with the usual automatic for preventing over-running in either direction. To the cable drums of each gyro is secured a pair of cables connected direct to the cable drum upon the engine, so that by operating the engine the gyros can be turned slowly back and forth upon their vertical pivots by means of cables lying in grooves, plainly seen in Fig. 8.

This oscillation constitutes the precession movements



Fig. 11.—Automatic Controlling Apparatus.

of the gyro, under constant and instant control in either direction.

AUTOMATIC CONTROL.

Several methods of automatic control have been investigated. Froude in 1873 developed an apparatus for simultaneously recording the rolling of vessels and the slope of the waves producing or contributing to such roll. In this apparatus lies a clue to one simple form of automatic control of the precessional movements of the gyros so as to measurably forecast or anticipate the rolling of the vessel.

A method, however, has been discovered of combining Froude's short and long pendulum in one comparatively simple apparatus and also greatly increasing the length of the long pendulum, as well as very materially augmenting its mass moment. This control is based upon the peculiar arrangement of two small gyroscopes weighing about ten pounds, and the pendulum so obtained represents a mass approaching half a ton with a pendulous length of ten miles. The control thus constituted has been finally brought to the point where it responds to only one component of universal angular motion. That is, it is not in the least affected by any amount of pitching of the ship or angles of yawing or azimuth or other movements. A close view of the apparatus is shown in Fig. 11. As indicated by results, this simple control apparatus causes the gyros to instantly neutralize the direct effect of all sea impulses. An eminent essential of such control apparatus is that it shall be independent of period and that it shall be free from any liability to harmonize with any periodic

motion of the ship. The operation of the device indicated that it successfully fulfils all these conditions.

One important feature of the active type of gyro is its power to artificially roll the ship on which it is mounted.

This feature is of great value when applied to ships in icebound waters, inasmuch as it enables them to keep free of the ice. In the case of the steamship "Ashtabula," we have a ship of about 5,000 tons displacement plying regularly between ports of this country and Canada across Lake Erie. Her general dimensions are as follows: Length, 370 feet; beam, 56 feet; displacement loaded, 4,500 tons; draught, 11 feet; period, from 5.5 to 6.6 seconds. In stormy weather she has rolled in the neighborhood of 35 degrees or through a 70-degree arc. In this instance and on Lake Erie this rolling is usually due to a succession of comparatively small increments, the magnitude of which has been ascertained.

In the appended table are shown the principal characteristics for an active gyro and for damping tanks of equivalent stabilizing power, which have been carefully calculated from known formulae, the analyses of which have been brought to conform exactly to the formulae of Mr. Frahm. The period of this ship varies from 5.6 to 6 seconds according to the number, weight and distribution of railway cars upon her four tracks. The total net load capacity of this vessel is about 1,500 tons. The tanks in each instance have been designed for taking care of one-degree wave slope increment. Since the trips are of comparatively short duration and the load varies through quite a large range, the adjustment of the tanks would be imperative to bring them into synchronism. There would be no reserve quenching power available in the tanks shown, the free space necessarily being small. There being no available space above the main deck for the tanks, they are placed below.

Keeping the characteristic displacement \times period \times M. G. constant, we have the following results as to tanks and gyro:

Even with these tanks it is doubtful whether sufficient resonance can be developed during the time when the boat has less than a 6-second period in the one case, or 6.6 seconds in the other.

In the "Ashtabula" extreme space requirements are not of great importance but the extra weight of the tanks and water would probably interfere with the

COMPARISON.—DAMPING TANKS AND EQUIVALENT GYRO STABILIZING PLANT, S. S. "ASHTABULA."

Period of roll.	Notes.	Weights in metric tons.			Percentage of displacement.	Space required.		Capacity for rolling ships.
		Water.	Tanks.	Total.				
6 seconds.....	Two tanks 60 and 40 feet long.	784	95	897	19.8	cu. m. 960	cu. ft. 33,180	None.
6.6 seconds.....	Two tanks 40 and 20 feet long.	490	65	555	12.4	626	21,600	None.
Complete Gyro Equipment.								
Any period....	One plant.	0	0	51	1.1	64	2,200	Through an arc of 8 to 10 deg.

boat's clearing the bar on the Canadian side.

Even in this extremely stiff ship, requiring relatively an unusually heavy gyro, the differential as to both weight and space stands out in favor of the gyro in marked contrast to the tanks. This is especially true when it is understood that the tanks will only function or perform half, and the more unimportant half, of the work easily performed by the gyro; that is, the tanks are only serviceable for stabilizing, whereas the gyro is originally intended for producing roll in the ship to prevent the ship from being caught in the ice or freezing solid in the process of forcing her way through heavy ice fields and especially wind row ice during the winter and spring months. For this latter purpose, however, it is found that a small gyro will perform all those functions, that is, the gyro illustrated here, while ample for stabilizing the ship, is much larger than is required for rolling. The gyro illustrated would only require to be run at one third or one half speed for the production of all the rolling that could ever be required by the "Ashtabula" in breaking through the heaviest ice. This is owing to its incessant action developing its full force in proper direction and with the proper emplacement upon each half period. Very heavy rolling can easily be produced and maintained. The action under these conditions is far simpler than in preventing roll, inasmuch as the reaction of the ship after rolling has started is found to react back to the gyro sufficiently to automatically control its precessional movements; usually in rolling only fractional speeds of the gyro are used.

Not the least interesting in connection with the "Worden" equipment were some gyroscopic pendulums employed in obtaining records of the motions of the "Worden." These recorders were originally designed by the

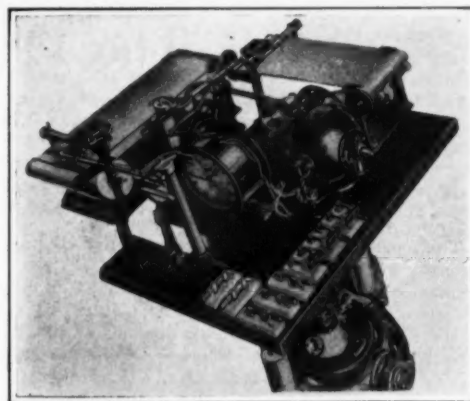


Fig. 12.—Roll and Pitch Recorder.

author to represent pendulums (though they are actually less than a foot in height) of very great pendulous length, namely, 1,000 miles, representing an artificial mass moment of $1\frac{1}{2}$ tons hung from the distance. In the earlier trials of this instrument it was found that there existed no necessity for so long a pendulum, and this was afterward reduced to the equivalent of a ten-mile pendulum. The records were obtained by the gyros thus arranged. In connection with this apparatus one point which is new and is of special interest is the elimination in the records of the influence of extraneous motion components reaching the instrument or influencing to the slightest extent the record itself.

For instance, if we are recording the roll of the ship, it is desirable that all motions relating to either the pitch or yaw or other azimuth movements should be eliminated and the apparatus be entirely free from disturbances from these or any other motions which do not represent the proper roll component. Two views of this apparatus are shown in Fig. 12 and Fig. 13.

Our knowledge of the amount of work derived from the active stabilizing gyros herein described, while acting under these new conditions, is now such as to enable us to calculate with all necessary accuracy the weight and space occupied in connection with any plant; also to predict with accuracy what the results will be, the amount of power required, and also to

prescribe, with a fair degree of certainty, about what stabilizing factor under the new *modus operandi* would be satisfactory with any given ship.

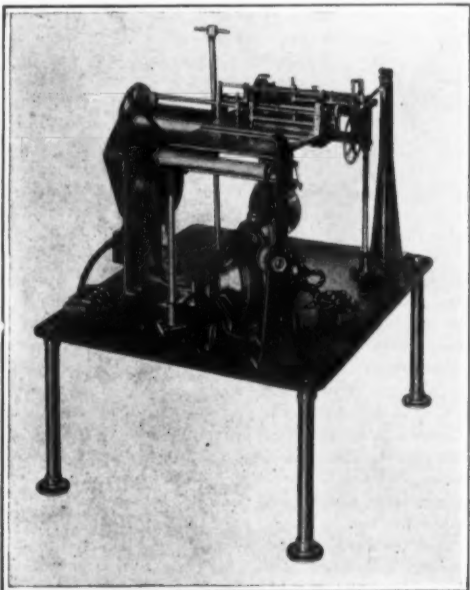


Fig. 13.—Apparatus Designed for Making Six Independent Records Upon the Same Tape, as Follows: Roll, Pitch, Spotting, Spotting the Roll Curve, Timing and Azimuth of Ship's Heading.

The Discovery of the Planet Neptune*

Was It Chance or the Result of Scientific Plan?

By David Rines

I. THE PUZZLING MOTION OF URANUS.

The annals of astronomy can boast of few events so wrought with dramatic character as the discovery of Neptune. The discovery of a celestial body is in itself a matter of no rare occurrence; but Neptune did not follow the common-place, prosaic methods of straying into the field of view of the telescope, or of unwittingly leaving a tell-tale impression upon the photographic plate. One of the foremost mathematical astronomers of his time, after a train of brilliant analysis and laborious calculation extending over a period of more than a year, directed the attention of astronomers many miles away to a region of the sky where, he asserted, would be found a new planet. Toward that region of the sky was pointed a telescope, and there, true enough, hung an additional member of the solar system. To intensify the situation, hardly had the world recovered from her thrill of astonishment, when the honors lavished upon the wonderful man who had thus discovered a planet without so much as placing an eye to the telescope were suddenly laid claim to in behalf of a youth until then unknown. To make the episode still more extraordinary, men of science had just begun to regain their composure when they were again startled by the leading mathematician of the western hemisphere darting forward boldly to challenge the claims of both men. The scientific world became bewildered.

The planet Uranus was the cause of the turmoil. Discovered in 1781 by Sir William Herschel, it became at once the object of much attention, solicitude and care on the part of astronomers. Telescopes were turned upon it nightly, its physical appearance was carefully watched, and its motion and position from night to night carefully recorded.

Within a few months of the planet's discovery, attempts were made to reach a rough determination of its orbit. This, for the time being, was assumed to be circular. As the path of a planet, however, although nearly a circle, is really an ellipse, the computations served merely as temporary approximations, awaiting the accumulation of a sufficient number of observations for the computation of the true orbit. The next two years brought forth from various quarters accurate elliptic elements.

Buoyed up by the hope that the planet, before discovery by Herschel, might have been observed as a fixed star, astronomers searched through the records of their predecessors, and were delighted to find their labors rewarded with the discovery of some twenty odd observations by Flamsteed, Mayer, Bradley and Lemonnier, extending over the period from 1690 to 1771.

Nine years elapsed, and observations were accumulating. The Academy of Sciences of Paris, deeming the data by this time sufficient in character and number for a fairly good determination of an orbit, proposed the theory of the planet's motion as the subject for a prize. Delambre carried off the prize as reward for a skillful mathematical treatment by which he deduced the elements of the planet's orbit and, with the help of these data, constructed tables for the planet's motion.

The utility of Delambre's work, however, was short-lived. The planet, though for a few years it faithfully conformed to the tables, soon disregarded the vast labors which Delambre had expended upon the computation of its orbit, and began to pursue a course totally different. In view of the fact that the tables were, after all, a crude attempt, because based upon comparatively few observations and uncertain data, their failure to predict accurately the motion of the planet did not cause surprise.

The computation of an orbit, it must be remembered, is quite complex. In accordance with the universal Law of Gravitation, a planet is influenced not only by the sun, but also by the other planets; and it is pulled by these planets considerably away from the theoretical ellipse determined by the action of the sun alone. The deviations—known technically as "perturbations"—thus introduced into the planet's path enormously complicate a problem otherwise comparatively simple; for not only is there necessary a knowledge of the sun's action, but also of the perturbations introduced by every planet large enough and close enough to exert appreciable influence.

As time went on, and observations continued to accumulate, and more nearly perfect information was obtained of the perturbing planets, and better theory was established, men of science began to feel that the time had arrived for a new discussion of the motion of Uranus. In the second decade of the nineteenth century, accord-

ingly, Alexis Bouvard attempted to construct a new set of tables.

He was much trouble over his inability to reconcile the ancient observations—that is, those made of the planet before the discovery of its planetary nature—with those of more recent date. The ancient observations, he found, could perfectly well be represented by points on an ellipse; so, too, could the observations of more recent date; but, strange to say, the two ellipses were not identical. Despairing finally of reconciling the two sets of observations, Bouvard, reluctantly contenting himself with the explanation that the older observations were less precise and therefore untrustworthy, based his tables exclusively on the newer data.

For a few years the planet revolved in the orbit determined for it by the new tables. Soon, however, it began, as on the previous occasion, to assert its independence. Before very long, therefore, Bouvard's Tables became as unreliable as those of Delambre.

The inexplicable wanderings of the planet, combined with Bouvard's unsuccessful attempt to reconcile the old with the new observations, could not fail to produce a profound impression upon the minds of astronomers. The accuracy of the computations was now almost certain. The trouble was not with the tables, but with the planet.

One more attempt was made to harmonize the theoretical with the actual motion of Uranus, but with no better result. A quarter of a century after the completion of Bouvard's Tables, his nephew, Eugene, upon undertaking a similar task, found as much difficulty in reconciling the new observations which had by this time accumulated, with those of his uncle's time, as the uncle himself had experienced when attempting to harmonize the observations of his day with those of Flamsteed's.

This last laborious but unsuccessful attempt to account for the motion of Uranus created dismay. LeVerrier, at the suggestion of his friend, Arago, the astronomical chief of France, dropped for the time his researches on comets to undertake the solution of the mystery.

II. AN UNDISCOVERED PLANET.

No one could have been found better qualified to undertake this task than Urbain Jean Joseph LeVerrier. The high order of analysis displayed in his mathematical astronomical researches bore witness to his worth as a practical mathematician, and as a skilled computer he stood unexcelled. Though but thirty-one years of age, he had already attained a place among the foremost of contemporary mathematical astronomers.

To assure himself that the deviations of Uranus from its computed path were not merely apparent, but actual, LeVerrier determined first on a thorough investigation into the accuracy of Bouvard's Tables. He consequently revised the theory and, after his own fashion, checked the computations. These lengthy preliminary labors served a purpose in that they allayed the suspicions of astronomers that the mystery of Uranus lay concealed in imperfections of Bouvard's Tables. They proved instead that the theory was at fault. But one conclusion was possible. Uranus moved in an orbit different from that determined for it by the sun and the known planets.

Arrived now at the stage where he was compelled to bring to his aid the hypothesis of an unknown force acting upon the wandering planet, LeVerrier began examining in detail the speculations of men of science regarding the nature of this force. One suggestion was that the Law of Gravitation, as enunciated by Newton, was not quite accurate; and that at a distance from the sun as great as that of Uranus, the consequent error introduced on the assumption that Newton's Law held good might become appreciable. A second hypothesis for the failure of the tables was that in their construction no account had been taken of the retarding influence of a rare ether, which those who held this view conceived to be diffused throughout space. Another conjecture was that Uranus had possibly been dragged out of its orbit by the perturbative effect of, or collision with, a passing comet; and still another explanation was that the planet was perhaps influenced by a large undiscovered satellite. Not a few astronomers hinted that Uranus was swerved from its computed path by the disturbing action of an unknown planet. Of the various hypotheses thus tentatively put forward, that of an unknown planet seemed to LeVerrier to be the most plausible; and he accordingly set himself the task of determining where in the heavens this planet might be found.

The task was not easy. The problem before him, known as the inverse problem of perturbations, was new; and though it can not be said to rank among the most difficult ever proposed, it was sufficiently difficult to re-

quire the skill of a master in astronomical researches.

It is not our purpose here to delve into mathematical intricacies; yet, in order to make the sequel more intelligible, we should not omit to mention one of the obstacles presented by the problem. The problem seemed impossible of solution without a previous knowledge of the distance from the sun of the unknown planet. In the absence of this knowledge it was necessary to guess a value for this distance. Should the guess, in the course of the solution, prove too large or too small, it would serve to suggest an improved value with which to solve the problem anew. An intelligent guess, therefore, would result in considerable saving of labor.

It had long before been discovered that the distances of the known planets harmonized with an empirical formula known as Bode's Law. It seemed reasonable to suppose that the unknown planet, too, would follow this law. If so, then the planet should be twice as far removed from the sun as Uranus. LeVerrier consequently decided, as a first approximation, upon a value for the unknown distance twice that of Uranus.

Many were the difficulties to be overcome, many the obstacles to be surmounted, many the pitfalls to be avoided. At one stage of the solution, LeVerrier became so discouraged that he did not advance a step in his researches for three whole months. Eventually, however, he solved the problem. The mystery of Uranus seemed at last explained. Its movements could be accounted for by the perturbations of a theoretical planet.

It is customary with investigators, in order that they may establish their title to priority, to publish news of their researches, either through the medium of the scientific journals, or by addresses before scientific societies. In accordance with this custom, LeVerrier on three different occasions reported his progress before the French Academy of Sciences. On November 10th, 1845, he presented that body with an account of his preliminary labors. On June 1st, 1846, he announced the results of a first approximation. And now, on August 31st, he presented the final results. On this occasion, he pressed upon astronomers the task of seeking for the planet with their telescopes. The further to encourage them, he declared that the object of their search could easily be distinguished, in a good instrument, from neighboring stars of the eighth or ninth magnitude, by the fact that, like other planets, it possessed a sensible disk.

It is regrettable to record the exceedingly slight interest aroused in men of science by researches so extraordinary. For one reason or another, whether because of the enormous difficulties entailed in the task, the lack of necessary appliances, or their incredulity, astronomers were backward in undertaking the search. LeVerrier became almost frantic in his appeals. At length his exhortations fell upon willing ears. In acknowledging the receipt of a scientific paper from Dr. J. G. Galle of the Berlin Observatory, he seized the opportunity to urge that the Berlin astronomers employ their telescope in a search for the planet. Galle, nothing loth, immediately set about looking for a chart of the heavens to aid him in the work.

Twenty years previously there had been inaugurated the construction of a series of star maps detailing specified portions of the heavens. The map of that region containing the position of LeVerrier's planet had been completed by Dr. Bremiker late in the year 1845, but it had not yet been distributed. Astronomers consequently were unaware of its existence. At the suggestion of a young student, d'Arrest—the famous astronomer of later years—Galle sought for and obtained possession of the map. On the evening of September 23rd, 1846, the very day on which he received LeVerrier's letter, he seated himself at the telescope, and called out the configurations of the stars in the field of view, as d'Arrest checked them off on the map. Close to the planet's theoretical position the observer found a star of the eighth magnitude which the assistant could not find depicted on the chart. Joy reigned! The object proved to be the planet.

The enthusiasm which seized upon scientific men, following the announcement that the planet had been actually detected with the telescope, stands out in marked contrast to the indifference and lack of interest which had prevailed previously. The whole world thrilled with wonder and amazement. Astronomers became lost in a frenzy of admiration and delight, and eagerly hastened to turn their telescopes upon the newly discovered inhabitant of the heavens. Not scientists alone, but men of all classes joined in paying tribute to the genius of LeVerrier. Everywhere the discovery was termed the most brilliant in the annals of astronomy, and it was rated the crowning achievement of the human intellect.

Suddenly, from across the English Channel came

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strange tidings. To the honor of discovery had appeared a rival claimant.

III. JOHN COUCH ADAMS.

John Couch Adams displayed while quite young a strong love for mathematics and astronomy. At ten years of age he had begun the study of algebra, as a boy he found pleasure in reading astronomical and mathematical works, and in his youth he derived untold delight from watching the heavenly bodies, computing their motions, and recording their positions with instruments of his own device. Though born of humble parents, his talents obtained early recognition, and it was accordingly decided to send him to college. Entering St. Johns College, Cambridge, at the age of twenty, he assumed at the start, and maintained to the end, the highest rank in his studies, graduating as first Smith's Prizeman and Senior Wrangler.

It was during the second year of his undergraduate career that chance directed to his hands a copy of Airy's report to the British Association on the progress of astronomy during the early years of the nineteenth century. In this report was mentioned the puzzling motion of Uranus, but without the least attempt to suggest an explanation. Deeply impressed, the young student seized in a flash of genius upon the true cause of the phenomenon, and fearful lest other matter should drive the subject from his mind, he was inspired to record the following memorandum:

"1841, July 3rd. Formed a design, in the beginning of this week, of investigating, as soon as possible after taking my degree, the irregularities in the motion of Uranus, which are yet unaccounted for; in order to find whether they may be attributed to the action of an undiscovered planet beyond it; and if possible thence to determine the elements of its orbit, etc., approximately, which would probably lead to its discovery."

Graduating in 1843, at the age of twenty-four, and finding himself at last with sufficient leisure to warrant his taking up the problem, he put his ideas into execution by attempting a rough test computation based upon the assumption that the orbits both of Uranus and of the supposed disturbing body were circular. For the radius of the unknown orbit he decided to adopt a value, in accordance with Bode's Law, double that of Uranus, and for the data to rely exclusively upon the modern observations. Encouraged by the results of the rough solution, he attempted a closer approximation; then, convinced by these two preliminary attempts that his hypothesis was based upon fact, he determined upon a more accurate solution.

This third solution he based on better data received from the Astronomer Royal, Sir George Biddle Airy, through the agency of their common friend, Prof. Challis, of the Cambridge Observatory. Though this solution proved unsatisfactory, it served to suggest slight improvements in method. Adams accordingly proceeded to a fourth, and this time was quite successful.

In September, 1845, more than a month preceding LeVerrier's paper on November 10th, and fully seven months earlier than that investigator's announcement, on June 1st, 1846, of the results obtained by his first approximation, Adams placed in the hands of Prof. Challis the elements of a theoretical planet, the perturbations by which, he claimed, would satisfactorily account for the motion of Uranus.

Possessed of but little initiative, Prof. Challis, upon receiving the solution, found himself unable to decide upon a course of action befitting the occasion. He made no telescopic search of the heavens. It was "so novel a thing," in his own words, "to undertake observations in reliance upon merely theoretical deductions; and while much labor was certain, success appeared very doubtful." It was at length decided to lay the matter before the Astronomer Royal, and Adams was accordingly provided with a letter of introduction.

Hoping that such a procedure might lead to instituting a search for the planet, Adams presented himself at the Royal Observatory, Greenwich, but learned that the head of the institution had some time previously departed for the Continent. He was invited to communicate with Airy by letter. Preferring a personal interview, however, he called again a month later; and finding Airy temporarily absent, he left his card with the statement that he would soon return. Upon his return he was informed simply that the astronomer was at dinner. Disappointed at the outcome of his visits, he left a paper containing the results of a fifth solution, and departed.

Airy had repeatedly dampened the enthusiasm of eager astronomers by his skepticism regarding the existence of an undiscovered planet. This skepticism was still unshaken. Further, Airy had discovered, in the thirties, that the motion of Uranus was faulty not only in longitude, but also in the matter of its distance from the sun. He now seized upon this fact to test the value of Adams' work. In replying to Adams, fifteen days after the latter's visit, he accordingly inquired whether the hypothetical planet, besides accounting for the mo-

tion of Uranus in longitude, would also cause to disappear the errors in distance.

To Adams the question appeared extremely trivial and evasive. He had hoped for greater encouragement. Already deeply hurt by his reception at the Royal Observatory—for he was of a highly sensitive nature—he found difficulty in replying to the Astronomer Royal, and in the several attempts he made he failed to persevere. Meanwhile, believing that he could obtain a slightly more satisfactory solution he started to solve the problem for the sixth time, and finally decided to postpone replying to Airy's letter until he could present the new results.

As for Airy, paying Adams no further attention pending the receipt of a reply to his letter, he took no steps either to commence a search for the planet, or to publish the results of Adams' calculations. This proved most unfortunate; for allowing LeVerrier time to step into the breach, it deprived Adams of claims to priority.

The publication of LeVerrier's paper of June 1st awoke Airy from his lethargy. Finding that the longitude of the theoretical body, as determined by LeVerrier, differed but little from that which Adams had communicated to him the previous October, he began to reflect whether, after all, there might not be some plausibility in the hypothesis of a disturbing planet. The fact that two investigators, working independently, and unknown to each other, could arrive at the same result, strengthened immeasurably the probability that both were right. He soon changed from a doubting skeptic, carrying words of discouragement, into a zealous believer intent upon converting others.

His enthusiasm aroused like emotions in Challis, and between them they began to devise plans for a search of the heavens. Challis was to drop all work not of an urgent nature, and undertake to map carefully all stars as small as the eleventh magnitude included within a large region of the heavens having for its center the theoretical position of the planet. The plan called for three different sweeps of the region. If a star found in the first sweep were missing from its place in the second, it would be inferred that the object was the planet, and in case of doubt, reference could be made to the third sweep.

It may be wondered why a search on so elaborate a scale should have been thought necessary. It was not expected that the body could be easily distinguished from neighboring stars of equal magnitude. The only recourse, consequently, was to distinguish the stranger by its motion among the fixed stars. With the appliances of our day, the planet could much more easily have been found with the aid of photography. In the absence of this aid the next most ready method was to compare the heavens with previously published charts, for the purpose of ascertaining whether there were a star visible in the telescope which was missing from the charts. This was the method employed later with such good effect by Galle. Unfortunately, however, the English astronomers, in common with astronomers of other countries, not only did not have in their possession a copy of Bremiker's Map, but they were even unaware of its existence. The only course open was to prepare a map of their own by observation from night to night, and the method they adopted for this, though elaborate, offered this advantage, that if it failed to disclose the planet, it would at least lead to the definite decision that no moving body so bright as the eleventh magnitude was to be found in the broad region of the heavens under consideration.

So immense was the task that Challis doubted whether he could complete it within a year, but nothing daunted, he set to work.

On September 29th, 1846, he received a copy of LeVerrier's paper of August 31st, and became much impressed with the French geometer's confidence that the undiscovered planet could be readily distinguished from neighboring stars through the fact that it possessed an appreciable disk. Adams had long before this concluded from his calculations that the brightness of the planet was at least as great as that of a star of the ninth magnitude, and had suggested that it might be picked up in the telescope by its physical aspect. Challis had preferred, however, from considerations of thoroughness, to follow the plan of observation originally adopted. Finding now Adams' belief corroborated from another source, he decided to act upon it. Directing the telescope that very night to the immediate neighborhood of the planet's theoretical position, he began scrutinizing in detail the larger stars. One out of some three hundred of these attracted his attention through the fact that it appeared to have a disk. It was the planet.

Alas for Challis' hopes! He was too late to claim the honor of discovery. The planet has been observed six days previously at Berlin. The news of Galle's good fortune put an end to the work at Cambridge. By that time, Challis had observed some three thousand stars, and was just getting ready to commence mapping. Going back over his notes, he found matter for deep vexation. Within the first four nights of observing he had recorded two positions of the planet, and had ob-

tained sufficient data to assure its discovery. Had he but looked over the records of his observations from night to night—labor postponed for more urgent work on comet reductions—he might have obtained for himself the glory now Galle's. Fate was unkind. With success all but assured, the faithful astronomer had failed.

If fate was unkind to Challis, how much more so was it to Adams! He was the first to solve the problem of Uranus, he was the first to make known the existence of the new planet, yet his researches had exerted not the least influence upon the actual discovery, and at the time of discovery, his name even was unknown.

For this state of affairs he was in no way to blame. He had solved his problem, and communicated his results to two of the foremost astronomers of Europe, one of them the official head of astronomy in England. Receiving but little encouragement, he had made no further effort to spread the news of his calculations, or to urge astronomers that they search for his planet. He had even intended, if no one else would do so, to undertake the search himself, and with this end in view, had actually had overhauled the instruments at St. John's College. Young, shy and sensitive, of a retiring and bashful disposition, unacquainted with the ways of the world, he had done his best. More could not have been expected.

The fault undoubtedly lay with the astronomers in whom he had confided. For almost a full year they had had in their possession data sufficient to assure discovery of the planet, and had failed until too late to act. Through their negligence, they had both deprived themselves of rewards now claimed by foreign astronomers, and had allowed a foreign mathematician to snatch from a young countryman the right to claim priority.

For these sins they received severe punishment at the hands of public opinion in England. It cannot be said, nevertheless, that they had wilfully neglected their duty. They were busy men. As Astronomer Royal, Airy had work sufficient on his hands. Challis, as director of the Cambridge Observatory, was actively engaged in furthering extensive researches on comets and asteroids. To start a systematic search for a theoretical planet meant to drop for an indefinite period other important work, and for months to devote endless labor and expense to a task regarding the successful outcome of which they were skeptical. It is to be noted, too, that once the probability of success became strengthened through the publication of LeVerrier's independent labors, they no longer hesitated.

The announcement of Adams' name as entitled to rank with that of LeVerrier in the story of the new planet awoke in France hostile and bitter criticism. And it must be admitted that there was just ground for complaint. The planet had been discovered entirely as a result of LeVerrier's researches, and in obedience to his earnest exhortations that the telescope be turned toward that portion of the heavens indicated by his theory. Previous to the discovery no mention had been made of Adams. The appearance now of a rival claimant to LeVerrier's honors seemed a dastardly attempt on the part of English astronomers to step beyond the fair limits of national rivalry for the purpose of robbing the French of their due.

English astronomers, strange as it may seem, were many of them no less opposed to Adams' claims than the French. If the latter were guided in their criticisms by a sense of injustice, the former were swayed by a warped feeling of national fairness. However mortified that the honors should have gone to a foreigner, they refused—and with some show of justice perhaps—to look upon Adams' communications to Challis and Airy as a publication, and conceded to LeVerrier the honor of being the sole theoretical discoverer of the planet.

Foreign astronomers on both sides of the Atlantic took a fairer view of the situation. Though recognizing that LeVerrier had established his title to priority through previous publication, they did not lose sight of the fact that Adams had in reality preceded LeVerrier in the theoretical discovery. They realized, too, that the fault was less Adams' than that of Airy and Challis. Their verdict has been upheld by later astronomers, but only after the lapse of years.

Adams himself took no part in the controversy. Not a word of criticism ever passed his lips; not an accusation did he ever make; not a man did he ever blame. Personally, he made no efforts in his own behalf. On the contrary, he awarded to LeVerrier "his just claims to the honor of discovery."

Upon the fortunate Frenchman the world heaped countless honors. From all directions came words of congratulation and praise. Scientific academies all over Europe and America vied with one another in hastening to elect him one of themselves. Prizes and medals came to him unsolicited. Kings paid him homage. It was even proposed that the planet bear his name. And Galle, too, received a share of the honors. Adams alone was neglected.

IV. LATER DEVELOPMENTS.

The accumulation of observations brought to light a

startling fact. The observations failed to conform to the tables furnished by the theory of Adams and LeVerrier! It was accordingly attempted to compute an orbit entirely independent of the theory, and based upon the observations only. The result was even more startling. The orbit, far from being quite elliptical, as predicted, was very nearly a circle, and with a radius much smaller than that indicated by theory.

Here indeed was a mystery. Relying upon predictions based upon calculations, astronomers had discovered a planet, only to find that the planet moved in an orbit totally different from that furnished by the calculations. LeVerrier and Adams had obtained an ellipse, with a mean distance from the sun nearly in accordance with Bode's Law. The actual planet moved in an orbit nearly circular and paid no attention whatever to the law!

The failure of Bode's Law, as indicated by the preliminary orbits of Neptune, came as a distinct shock. Astronomers refused to believe, and preferred to distrust the orbit computations.

To obtain a better orbit, there was only one of two things to do: to await the accumulation of a number of years' observations or, as was the case with Uranus in the early years following that planet's discovery, to search through the old star catalogues in the hope of finding observations of Neptune unwittingly recorded there as of a fixed star.

Such an observation was actually discovered. Two astronomers, working independently and by different methods, the one at his desk, and the other with his telescope, the one in America and the other in Europe, came almost simultaneously to the same conclusion, that a star recorded as observed on the night of May 10th, 1795, in a position of the heavens where Neptune had probably at that time had its course, was now missing from the firmament. A little investigation showed this star to have been the planet. It showed further that had the observer exercised a little more care he could not have failed to anticipate the discovery of Neptune by fifty years.

The discovery of this observation, by extending the observed arc of Neptune over one third of the planet's course, furnished ample material for the computation of a good orbit.

These curious developments had meanwhile aroused the interest of Prof. Benjamin Peirce, and this eminent American mathematician now turned the glare of his profound intellect upon the problem of Neptune. Following upon a long series of researches, he announced one evening to a learned audience that:

"The planet Neptune is not the planet to which geometrical analysis had directed the telescope; that its orbit is not contained within the limits of space which have been explored by geometers searching for the source of the disturbances of Uranus; and that its discovery by Galle must be regarded as a happy accident."

This statement, apparently grounded upon firm analysis, and coming from a recognized authority, astounded the world. And no wonder. LeVerrier had predicted the position of an undiscovered planet; the prediction had been made independently some months earlier by another investigator, Adams; and in the predicted place, and having the predicted attributes, the planet had been found. Men had marvelled, and termed the discovery of the planet a wonderful witness to the power of the intellect. Were they now to believe that so sublime a discovery was, after all, nothing more than a "happy accident?"

It often happens that a mathematical problem affords more than one solution. Such, said Peirce, was the case with the problem of Uranus. The irregularities in the motion of Uranus could be accounted for by the disturbing action of any one of several theoretical bodies. The actual planet Neptune is such a body; so also is the hypothetical planet of Adams and LeVerrier. The "happy accident" lay in the singular circumstance that these two solutions of the problem, though differing widely in every other particular, agreed at the time of discovery in the matter of their direction from the earth, so that a telescope pointed at one pointed also at the other. As for the coincidence that LeVerrier and Adams had arrived at the same solution, that was to be explained by the fact that in their researches they had both been led astray by too firm reliance upon Bode's Law.

Peirce went further and assailed the theory employed by LeVerrier and Adams, maintaining that in their investigations they had employed inaccurate formulæ. Though the justice of this criticism has been questioned, later developments seem to indicate that the criticism was not unfair. "Nor can I believe," says the present Astronomer Royal of Scotland, "that if Adams or LeVerrier could have foreseen the immense difference of form between their own formulæ and the truth, they could have had the same confidence in the exactness of the predicted places."

Throughout the bitter controversy that followed, Peirce at no time contested the genius of the theoretical

discoverers. He drew a sharp distinction between the task of the mathematician and that of the astronomer, and pointed out that Adams and LeVerrier, in demonstrating the existence of a disturbing body, and obtaining a solution which, though hypothetical, could have accounted for the motion of Uranus had it had a real existence, had performed the task required of the mathematician, and were consequently entitled to all the praise and reward that would have been theirs had the solution proved to be the actual solution of nature.

LeVerrier, nevertheless, did not take kindly to the criticism. He was unwilling to grant that Neptune was not the planet of theory. He refused at first to admit that Neptune moved in any other than the predicted orbit; and casting slurs upon the orbit computations declared that the results of the computations were incompatible with the nature of the perturbations of Uranus. Forced eventually to retreat from this position, he hit upon the explanation that just as Uranus was influenced by Neptune, so Neptune perhaps was disturbed by a trans-Neptunian planet. The hypothesis of a trans-Neptunian planet became untenable, however, when Peirce showed that Neptune, though moving in an orbit different from that predicted, could account for all the perturbations of Uranus with the most surprising accuracy. LeVerrier accordingly reverted to his former stand, and maintained stoutly that Neptune was none other than the predicted planet.

Adams, unlike LeVerrier, took no part in the discussion. It was not until many years later, and then upon a most fitting occasion, that he took it upon himself to remark that though in certain particulars Peirce was right, yet so far as the problem under consideration was concerned—the problem of assigning a position in the heavens where the theoretical planet might be sought for—the criticism was without force. Though admitting that in the discovery of Neptune there was an element of chance, he nevertheless joined his impulsive French contemporary in the assertion that Neptune and the predicted planet were the same.

To what extent the discovery of Neptune was fortuitous is a question perhaps still open to argument. Certain it is that both Peirce and LeVerrier, in course of their controversy, gave utterance to statements apparently paradoxical and self-contradictory. Peirce maintained to his dying day the accuracy of his views; and this after he had resumed his researches, and carried them on extensively. Other astronomers, on the other hand, have as firmly maintained the contrary.

Astronomers of the present day have little faith in the existence of more than one solution. Unfortunately, Peirce never published more than a very brief summary of only a portion of his researches. It is devoutly to be wished that some competent mathematician would investigate the original manuscripts.

V. CONCLUSION.

A word with regard to the supposed trans-Neptunian planets.

Ever since the discovery of Neptune, astronomers have lived in the hope of finding a planet even more remote from the sun. LeVerrier himself was perhaps the first to express this hope, and uttered the remarkable thought that the existence of this planet might be detected mathematically, though it be too small and too far away to permit of telescopic vision. Several astronomers have done considerable work on the problem, but the telescopic search of the heavens based on their researches has proved fruitless.

Whether or not a trans-Neptunian planet has actual existence must be left for time to tell. Of one thing, however, we may rest almost certain. The circumstances attending the discovery of such a planet will hardly be of so extraordinary a nature as those interwoven with the discovery of Neptune.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

A Strange Case of Abnormal Anatomy

[In our issue of March 1st, we had occasion to report on a strange case in which the internal organs of a patient were found to be completely reversed as compared with the normal left and right relation. We have received the following very interesting letter, from which it will be seen that a similar case has been observed in this country, in fact, the letter comes from the subject himself.—EDITOR.]

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT: Regarding the note on "A Strange Case of Abnormal Anatomy," published in your issue of March 1st, I wish to say that strange things sometimes are found in America. The undersigned (now thirty) has known for 15 years that his heart is on the right of the median

line. But stranger still, I was operated on for peritonitis March 11th, 1912, when the two attending physicians found that I had no appendix—they having decided to remove it so as not to cause me trouble later in life. Further, they found my intestines exactly reversed, even to the large intestine leading from the stomach. I have no ill effects from such disarrangement of anatomy, and am a postman in this city, making my two trips each working day. I thought this might be interesting to you. HARVEY J. HAYES, Pasadena, Cal.

Hygiene and Mortality.

THE National Brotherhood of England has made a study of the health conditions in Derby, England. The city was divided into four districts, in which the following conditions were observed:

No. of District.	Population.	Deaths in One Year.	Deaths per Year per 10,000.	Mean Length of Life.
1	31,754	335	106	47
2	32,812	404	123	40
3	31,018	417	134	37
4	28,741	474	165	30

It will be seen that the mean length of life varies within wide limits—the minimum and maximum differ by no less than seventeen years.

We wish to call attention to the fact that we are in a position to render competent services in every branch of patent or trade-mark work. Our staff is composed of mechanical, electrical and chemical experts, thoroughly trained to prepare and prosecute all patent applications, irrespective of the complex nature of the subject matter involved, or of the specialized, technical or scientific knowledge required therefor.

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